WP0118

Dodge® synchronous belt drives: advantages in air handling applications

Dodge Customer/Order Engineering
04-11-2011

Since their invention, v-belts have been the drive of choice for commercial and industrial air handling applications. That is not terribly surprising considering the benefits provided over the flat belts they replaced. With narrower widths, lower tension, higher horsepower capacity, improved misalignment capability, longer life, higher efficiency, and low cost, v-belts were the clear choice.

Minor improvements have been made in the construction and manufacture of v-belts over the years, but the basic design has remained relatively unchanged. Synchronous belts, while not a new technology, have seen significant improvements in recent years. Today's synchronous belts offer higher efficiency than v-belts, narrower widths, lower static tension and belt pull, lower operating temperatures, and reduced maintenance expense, as well as reduced noise over previous generations of synchronous belts. With all these benefits, can synchronous belt drives replace v-belt drives as the industry standard in air handling applications?

Energy Efficiency

Synchronous belt drives have always offered low cost energy savings over v-belt drives. As with most other systems, the primary form of energy loss in belt drives is heat generated by friction. There are three primary sources of frictional losses with belt drives; internal friction due to belt flexion, friction due to belt tension and contact of the belt and pulley, and slippage.

During operation belts are put through a constant cycle of flexing and relaxing as they pass around pulleys and through straight sections. When this occurs, internal friction produces heat. Standard V-belts, because of their design and geometry, have the greatest resistance to bending and thus produce the largest amount of heat. The advent of cogged v-belts represented an improvement in losses due to bending stress. Simply switching from a standard V-belt to a cogged V-belt can increase efficiency by about 2%.

Synchronous belts are also cogged by nature and feature a much flatter design which greatly reduces internal bending stresses. Improvements to materials used in synchronous belt construction have further reduced these bending stresses. Some of the first generations of high capacity synchronous belts utilized stiff aramid fibers as the tensile members. More recent designs utilize more flexible advanced fiberglass or "carbon" tensile members to reduce bending stress and improve efficiency.

V-belt drives rely entirely on friction created by the wedging action of the belts in the sheave grooves to transmit power. Synchronous drives feature a positive drive design; they have teeth to transmit the required torque. Friction is significantly reduced by lower belt tension and smaller contact area. Newer synchronous drives utilize low friction facing materials, where the belt contacts the sprocket teeth, to improve wear resistance, belt life, and further reduce friction.

The friction required to transmit torque with v-belts is obtained through proper tensioning of the belt. Standard v-belts, however, can stretch up to 3% of the original length throughout the life of the belt. If proper tension is not maintained, belt tension drops and the belt can slip. When slip occurs, additional heat is generated between the belts

ABB Motors and Mechanical Inc.
6040 Ponders Court
Greenville, SC 29615
Phone: +1 864 284 5700
Email: DodgeEngineering@abb.com

and grooves. Slippage can also occur during torque spikes, such as at start-up. Properly selected and installed synchronous belt drives will not slip.

At the time of proper installation, V-belt drives can run between 95-98% efficiency. The efficiency then falls to an average of approximately 93% during normal operation. Without regular maintenance, actual v-drive efficiency can drop to as low as 80%. Synchronous belt drives consistently operate at an average of 98% efficiency. Synchronous belts are therefore, on average, at least 5% more efficient than V-belts.

Belt Width

One of the drawbacks to the first generations of synchronous belts was with belt widths. The first synchronous belt drives were made from steel wire and then fiberglass. To obtain the required horsepower capability, synchronous belts had to be quite wide compared to v-belts. In an industry like air handling, where space is at a premium, size matters. Not only is the physical size a problem, but wider belts meant higher belt tension, increased bearing loads, and installation issues.

The best synchronous belts today can replace chain, and in some cases gears, due to their high tensile strength. While most air handling applications do not require such high HP capability, the added capacity has allowed belt manufacturers to make ever thinner belts. These thinner belts can mean not only smaller drive packages, but reduced belt tension and bearing loads.

Belt Tension and Bearing Loads

The first generations of true high capacity synchronous drives began to solve the issue of belt width, however, belt tension was often much higher than with v-belts. Part of the problem was with the way in which belt manufacturers calculated installation tension. Belt tension was calculated using the design horsepower, like v-belts, rather than motor or brake HP. In addition, the aramid tensile fibers used in some of the first belts tended to relax, or settle, during a break-in period. This led to over tightening of belts such that proper tension was maintained after break-in.

V-belts require additional tension to be able to handle normal application loads without slipping. It was determined that synchronous belts, due to their strength and positive engagement, can handle these variations in load without increasing belt tension. Tension is only required to keep synchronous belt properly meshed with the sprocket. Manufacturing technology has also improved, preventing adverse settling of the tensile fibers within the elastomeric casing. They can be run at lower tension without fear of tension loss.

Thinner belt widths and lower belt tension have a dramatic effect on bearing reaction loads. For a given pulley diameter and HP requirement, a synchronous belt drive will reduce the value of the overhung shaft load by approximately 15%. Using a thinner belt moves this overhung load closer to the supporting bearings. The result can be dramatically reduced bearing loads, which leads to longer bearing life and reduced temperature.

Operating Temperature

Since efficiency loss equates to heat generation in belt drives, one would expect to see a difference in operating temperature between V-belts, cogged V-belts, and synchronous belts. This rationale holds true as V-belts generally run 40–80°F above the ambient temperature, cogged belts approximately 30–50°F above ambient, and synchronous belts only about 20°F above. Combined with lower bearing operating temperatures, synchronous belt drive packages can significantly reduce operating temperatures; a distinct plus in air conditioning applications.

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Reduced Maintenance Expense

Unlike v-belts, which require periodic inspection and re-tensioning, a properly sized synchronous belt drive will not require any re-tensioning. With improved bearing life, maintenance requirements are further reduced, making synchronous belt drives ideal for those applications where regular maintenance is impractical or unlikely.

Reduced Noise

First generation synchronous belts were generally considered very noisy. Significant improvements have been made since. To understand these improvements, it is helpful to understand the primary factors which influence synchronous belt noise. The primary mechanism by which synchronous belt noise is created is through meshing of the teeth between belt and sprocket. Noise generally increases with increases in belt speed, tension, and width and decreases in sprocket diameter.

In an effort to improve horsepower capability and synchronous belt life, the profiles of both the belt and sprocket teeth have undergone several changes. Long ago are the days of trapezoidal teeth. These improvements have changed the way the belt teeth enter and exit the sprocket and, with that, reduced belt noise. However, the most significant improvements in noise reduction have occurred as a result of higher belt capacities. In most cases there is not much that can be done about speed. Higher strength belts, though, have allowed the use of lower tensions and significantly thinner belts. While these high capacity belts have allowed the use of smaller diameter sprockets for a given horsepower requirement, in terms of noise it is better to use larger sprockets and thinner belts.

Synchronous belts drives will not be right for every air handling application. In some cases, belt slip in peak torque situations may be desirable. Improvements in synchronous belt life have been made, however v-belts will, on average, last longer than synchronous drives. Synchronous belt drives will most likely always produce more noise than v-belts, but in many cases, noise caused by the fan operation will be greater than the belt drive. The initial drive design can also be manipulated to help minimize noise. Initial costs will usually be higher than v-belts. However, with reduced maintenance costs and efficiency savings synchronous drives will provide a significantly higher TCO solution for both new and retrofit applications. Synchronous belt designs have improved a great deal in recent years and with benefits like higher efficiency, narrower widths, lower static tension and belt pull, lower operating temperatures, and reduced maintenance expense, they should be considered as a replacement for v-belt drives in many air handling applications.

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