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White Paper: Influences on Bearing Life in V-Belt Applications

Summary

For any given rotational speed and level of cleanliness, a ball bearing's service life is strongly influenced by the radial loads and temperatures to which it is exposed.

In applications where V-belts chronically slip, many operators find that their bearings prematurely fail. This can be especially costly and disruptive when the bearing failure occurs inside a gearbox.

In applications like these, Vulcan Grip® dramatically increases bearing life because it eliminates V-belt slippage and the accompanying frictional heat without the need to over-tension V-belts.

In this white paper, we show how V-belt tension affects "overhung load" on bearings, why systems with chronic slippage problems put operators in a no-win situation with belt tension, what happens with frictional heat load, and how Vulcan Grip interrupts these thermo-mechanical problems.

Radial load vs. bearing life

Pulleys have bearings positioned very close to them. The service life of ball bearings decrease at logarithmic rates with increasing load. See *Fig. 1*, below.

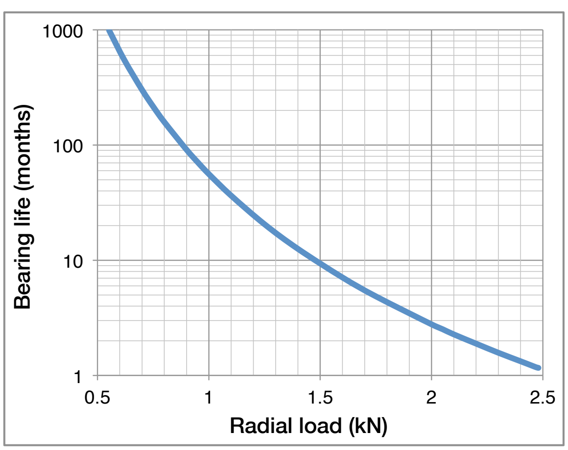

Figure 1 The service life of a deep-groove ball bearing with a bore diameter of 20 mm decays logarithmically under increasing load. At 0.9 kilonewton (202 lbs), this bearing has a service life of 90 months (7½ years). However, it lasts only 9 months at an unremarkable looking 1.5 kN.

Belt tension

Any equipment operator who has been responsible for maintaining a machine with a V-belt that chronically slips knows that greatly increasing the tension doesn't last; the belt soon slips again.

In a well-designed V-belt system, belt tension can be adjusted so the slack side has one-fifth the dynamic tension of the taut side. See *Fig. 2*, below. Importantly, this tension should endure for a reasonably long maintenance interval.

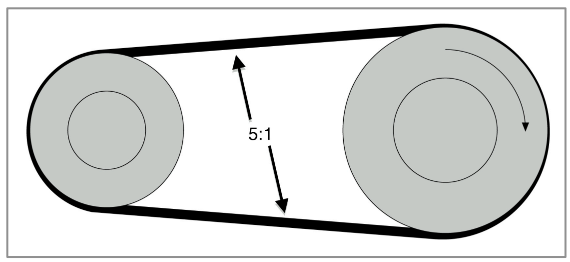

Figure 2 A properly designed V-belt drive system has a dynamic tension ratio of 5:1. The torque applied into the driver pulley on the right induces four units-worth of tension in the taut side (top arrow). By adding two units-worth of static tension when the machine is being set up, one obtains a taut-side tension of five units and a slack-side tension of one unit; the optimum 5:1 dynamic ratio.

Unfortunately, not all V-belt-driven machines are well designed. Why? There are many reasons, but a notable one originates with "horsepower wars" by the manufacturers of V-belts. It is natural for a machine designer to refer to the specification tables in a catalog from the V-belt manufacturer who shows the highest powers being transmitted. These performance tables assume optimum conditions. Also, the underlying friction factor used while generating the tables is carried out to four decimal places! Real life is never so precise and is seldom optimal.

In under-designed equipment, the belt slips, which generates heat. That in turn causes the belt to harden due to an effect called thermo-oxidation. The reduced belt friction necessitates *even greater* belt tension.

In many cases, this runaway vicious circle of increasing thermo-oxidation, more slip, and escalating belt tension results in belt strand tensions reaching a point where even modern, aramid-corded belts will stretch.

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This vicious circle means the radial load on the ball bearings supporting the driver and driven pulleys are seldom as envisioned. As can be seen in *Fig. 1*, even brief exposures to loads 50–100 percent greater than originally intended will severely degrade bearing life.

Moreover, once the V-belt relaxes and again begins slipping, these brief periods of overly high tensions are followed by protracted periods of excessive heat conducting from the pulley into the bearings. An increase in bearing temperature of only 38 °C (an additional 68 degrees F) can cut bearing life eight to ten fold!

Overhung load and radial load

Since 1917, the coefficient of friction between pulleys and rubber V-belts has been a fixed value, not a variable that could be improved. Until now, the only "proper" way to address an under-designed V-belt system was to redesign it with a wider belt and a more powerful tensioner.

Clearly, such an undertaking is seldom viable since more belt tension will obviously increase the radial load on bearings. Moreover, there is a detail that compounds radial load on the bearings: the geometry underlying "overhung load." Increasing the belt width exacerbates this geometry. Why?

Machine designers know that the radial load on bearings is influenced by the geometric relationship of the bearings and pulley (see *Fig. 3*, below).

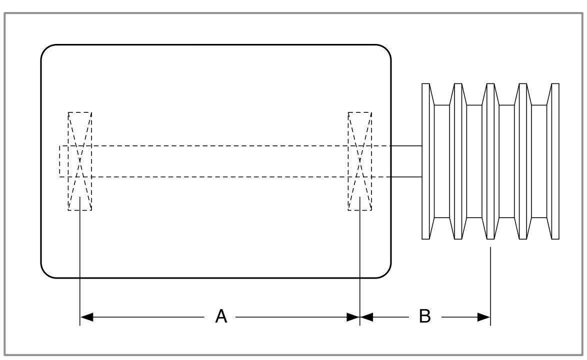

Figure 3 Overhung load is influenced by the ratio of *B* (the distance from the center of the pulley to the nearest bearing) vs. *A* (the distance between bearings).

As the V-belt's width increases (which requires a commensurate increase in belt tension), the centerline of the pulley moves farther away from the nearest bearing. This adversely affects the *B/A* ratio shown in *Fig. 3* and *even further* increases the overhung load (radial load) on the bearing nearest the pulley.

The result of all these compounding factors is that shafts, bearings, tensioners, and related componentry must all be increased in size; these cascading effects are costly. This reality underlies why the OEMs often decided not to undertake the task of improving their products themselves.

How does Vulcan Grip increase bearing life?

V-belts rely solely upon friction to function *at all*. With Vulcan Grip, the coefficient of friction between pulleys and V-belts is no longer the same fixed value used by machine designers since 1917. Friction is now a *variable* that can be improved—dramatically.

Maintenance personnel can now retain their stock belt widths (and tensioners, bearings, etc.). Belt tensions can be set to the optimal 5:1 dynamic tension ratio and they *stay there*, without slipping.

Operators no longer suffer the vicious circle of slip, heat, thermo-oxidation, overheated bearings, excessive belt stretch, frequent belt tensioning, overloaded bearings, and all the attendant maintenance costs and disruption to production schedules.