BISHOP WISECARVER

WHITE PAPER

SELF-CLEANING GEOMETRY OF VEE GUIDE BEARINGS

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INTRODUCTION

Bearings are fundamentally important to automated equipment because they enable repeatable and accurate motion. The wide variety of bearing designs is a testament to their importance. Each version has specific benefits and use cases where their utilization will provide the best performance over time. In general, the benefits of a particular bearing originate from the basic geometry and from the material specifications of the components.

Linear guide bearings are designed to provide low friction motion in a single direction of travel and are most often the building blocks of reciprocating motion. They are available in a variety of geometries and internal arrangements and are made from various base materials ranging from polymers to high hardness steel. The linear guide bearing includes wheel bearings and specific linear track surfaces with matching geometry to roll or slide upon. Common geometries include square rail, round shafting with round bushings, round shafting with gothic arch U-groove wheels, flat bearings with flat track surfaces, and vee wheels with vee tracks or vee track channels.

Vee guide bearings are the best choice when motion is needed in debris laden environments because they can operate with limited protection over long maintenance intervals as the motion tends to expel debris from the track surface. Other linear bearing designs often fail prematurely and unexpectedly when utilized in harsh and dirty operating environments. Systems not designed for harsh environments typically fail as a result of ingress to the bearing internals, deteriorating the lubrication; accelerated wear of the outer surfaces due to abrasion; or binding of the motion system due to debris buildup.

The vee guide wheel bearing exhibits unique performance characteristics when rolling on the matching linear vee tracks that other designs don't duplicate. Most notably, a self-cleaning debris wiping action is generated as the wheel rolls as a direct result of the angled geometry.

This white paper will explain the self-cleaning properties that are generated by the contact geometry of vee shaped guide wheel bearings.

CONSTRUCTION AND GEOMETRY

DualVee® Linear Guide Wheels from Bishop-Wisecarver® are double row angular contact ball bearings that are available with a variety of protection options including seals, shields, seal/shield combination, and a double seal for washdown applications. The critical internal components including the bearing balls and grease lubrication are located inside the bearing cavity and are protected from external debris by the seals or shields. *See Figure 1*.

FIGURE 1

Vee guide wheels and vee guide tracks are made from hardened steel or hardened stainless steel to increase the load carrying capacity and to extend the service life. These materials are typically harder than most types of debris including cardboard fibers, saw dust, cutting dust, shop grit, food ingredients, and soil. Some materials may be extremely hard including ceramic or metal powders, sanding grit, or stone and tile dust, but most of these materials tend to be clumps or nodules that get ejected rather than crushed by the guide wheel.

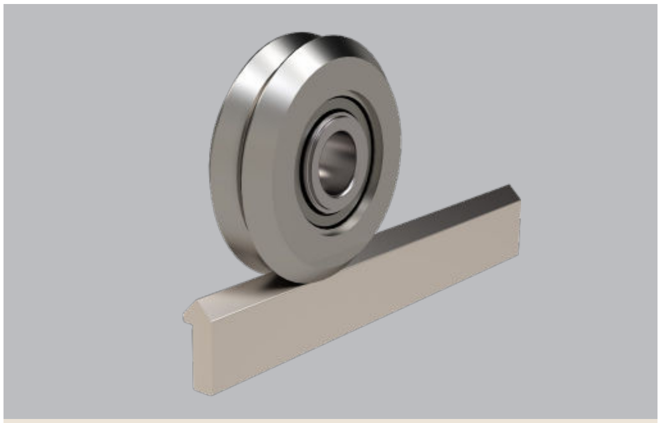

FIGURE 2

The vee guide wheels feature an outer bearing race with 90-degree surfaces that are designed to roll on matching 90-degree linear guide track. *See Figure 2*. Unique self-cleaning properties allow the wheel-to-track interface to be exposed to debris contaminated environments because the rolling action tends to wipe the running surfaces clean. The engagement of the vee guide wheel to the linear vee track makes line contact where the surfaces touch which helps to spread the load over a longer surface. The angles of the vee surfaces and the line contact patch geometry provide the source of the self-cleaning action.

CONSTRUCTION AND GEOMETRY (CONT'D)

If you take a close look at the end view of a vee guide wheel sitting on the linear vee track you will see two surfaces in contact. *See Figure 3*. Identify two points along the wheel-to-track interface with one near the peak of the vee (P1) and the other point near the edge (P2). Now measure the distances from the centerline of the bearing bore to both P1 and P2 to come up with the radii R1 and R2 respectively. Because of the angled surface R2 is a greater distance than R1 from the centerline and therefore R1≠R2. *See Figure 4*.

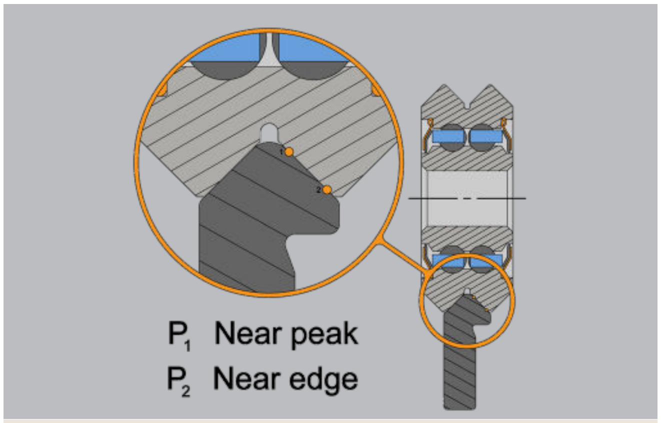

FIGURE 3:

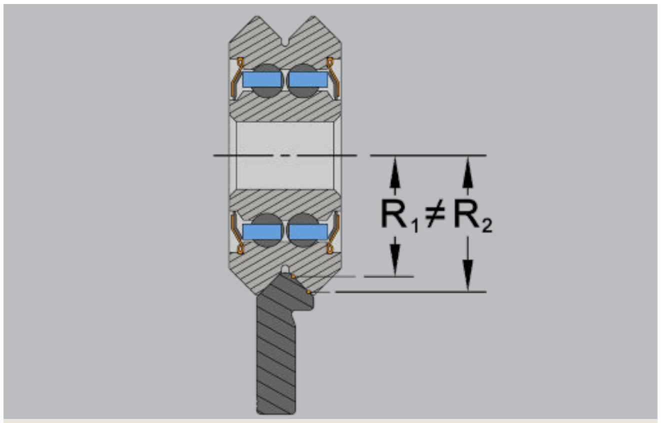

FIGURE 4:

Next, visualize the size view with guide wheel bearing rolling one revolution. *See Figure 5*. Consider the distance traveled by the two points located on the circumference of the vee wheel. A dot marked at the points would move in a ***cycloid*** as the wheel rolls. P1 would travel distance D1 and P2 would travel distance D2. Because R1≠R2 it is also true that D1≠D2. In fact, because P1 is located near the peak of the vee it is closer to the centerline, and so it will travel a slightly shorter distance. D1<D2. Therefore, the P1 point near the peak will travel less distance per revolution, or slower, than the P2 point near the edge that will travel more distance per revolution, or faster.

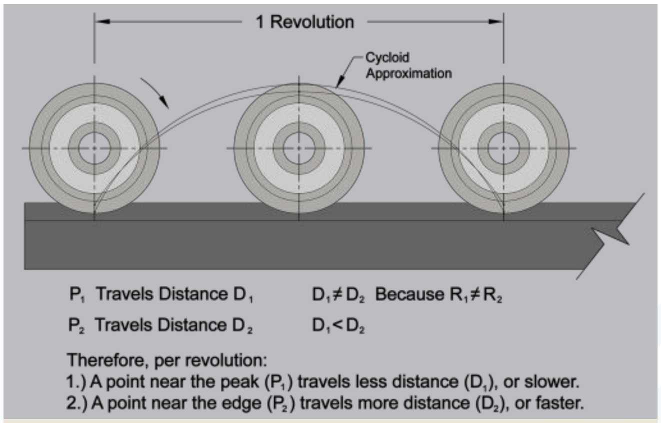

FIGURE 5:

The difference in peripheral speed is considered a ***velocity gradient***. *See Figure 6 next page*. Additional imaginary points along the contact surface can be thought of as having higher and higher velocity as you move toward the edge. This phenomenon is a direct result of the geometric shape of the outer race of the guide wheel bearing. An angled track surface is less likely to have contaminates settle and stay on the surface

CONSTRUCTION AND GEOMETRY (CONT'D)

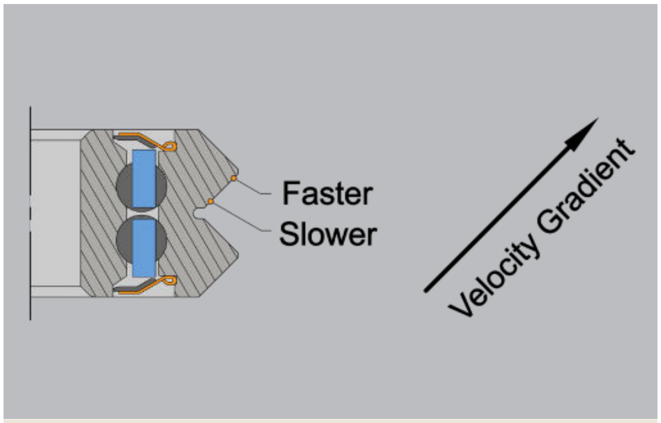

FIGURE 6:

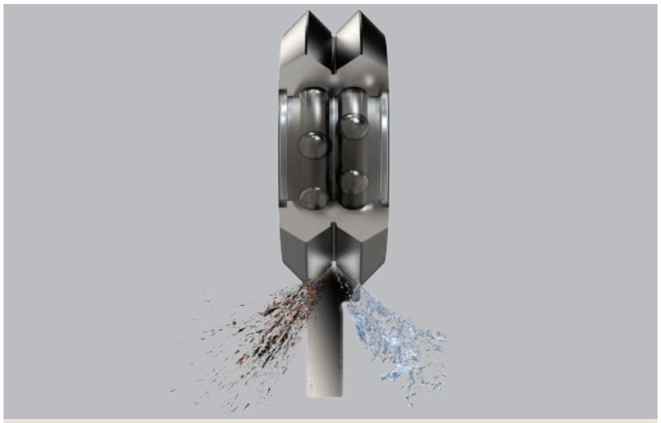

FIGURE 7:

and when the guide wheel rolls along the angled vee track, any accumulated debris is accelerated or swept from the peak of the vee to the edge. Most common debris is ejected during use and is what we observe as the self-cleaning action that is the inherent key benefit of vee guide wheel technology.

Additionally, the angled vee surfaces of the guide wheel approach and depart the wheel-to-track interface at a very shallow angle. Larger debris often makes first contact with the guide wheel at the upper portion of the debris where the shallow angle imparts ***topspin*** that causes the contaminate to tumble away.

Linear guide wheel bearings with the vee shaped outer race profile are the only type of linear bearing with self-cleaning geometry. Other common linear guides must rely upon mechanical scrapers to push debris ahead of the contact patch. These designs have limitations in their debris tolerance and often fail prematurely when faced with small particle size such as powders. Additionally, liquid ingress into linear guide bearings is a concern because fluids can rapidly degrade and contaminate the grease to the point where metal on metal fatigue causes failure.

Vee guide wheels and vee tracks are offered in several common vee angles. Bishop-Wisecarver® DualVee®, MadeWell®, UtiliTrak®, and MinVee® all feature 90-degree vee angles. HepcoMotion® features 90-degree vee angles on large capacity versions, and 70-degree vee angles on lower capacity versions. Other industry offerings include 60-degree angles among others. All vee profiles will exhibit the self-cleaning principle as the guide wheel rolls on the vee guide track, providing the best performance and longest service life when operated in harsh and debris contaminated environments. *See Figure 7*.

FREQUENTLY ASKED QUESTIONS

Q: What is the coefficient of friction for vee guide wheel technology?
A: Between 0.005-0.02 when operated on matching vee guide track.

Q: Are there benefits to the different vee angle designs?
A: When vee guide wheels are loaded, the highest stress occurs at the apex of the inner vee. The 90-degree vee in DualVee® wheels creates a lower stress concentration at the apex than the 70-degree vee (assuming identical apex relief radii) and exhibits less of a resultant "outward wedge force" on the wheel.

Definitions:

- Cycloid – The curve generated by a point on the circumference of a circle that rolls along a straight line.
- Topspin – A property of a ball that rotates forward as it is moving.

ABOUT

Bishop-Wisecarver develops innovative motion solutions that are expertly designed and delivered to perform from a company you can trust. Leveraging nearly 70 years of experience, we've earned the reputation of providing unmatched quality, reliable service and engineering support for every stage of a customer's design cycle. No matter your application, volume shipment requirements or extreme environmental conditions, Bishop- Wisecarver listens to your specific needs and delivers innovative solutions.

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