EXPECT INCREASED EFFICIENCY WITH HYPOID GEARING INSTEAD OF WORM GEARING

WHITE PAPER

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INTRODUCTION TO RIGHT-ANGLE GEAR TYPES

A gearbox is used to increase torque or change speed (revolutions per minute, aka RPM) of a motor to fit a particular application. The gearbox is attached to the motor shaft and provides a given output torque and speed, as determined by the gear ratio.

A right-angle gearbox can transmit torque and RPM at a 90-degree angle (turn the corner). There are several types of right-angle gearboxes, including straight bevel, spiral bevel, hypoid and worm. The primary differences among them are in how the gear sets are cut, as well as the styles in various stages.

- Straight bevel gears (Figure 1) represent the simplest and most common form of bevel gear. They have straight teeth and are parallel to the generators of the cone. A straight bevel gear has a 10:1 ratio range. A straight bevel gear is approximately 96% efficient per stage.
- Spiral bevel gears (Figure 2) are a variation of straight bevel gears. They have curved oblique teeth on which contact starts at one end of the tooth and progresses smoothly to the other end. They produce less noise and vibration when compared to the straight teeth of a straight bevel gearbox. A spiral bevel gear has a 10:1 ratio range. Like the straight bevel gear, a spiral bevel gear is approximately 96% efficient per stage.
- A hypoid gear (Figure 3) is a type of spiral bevel gearbox, with the difference being that hypoid gears' axes are in parallel planes but do not intersect. In other words, the axes of the hypoid gear are offset from one another. The shape of a hypoid gear is hyperbolic; the shape of a spiral bevel gear is normally conical. A hypoid gear has a 25:1 ratio range. A hypoid gear set, in this ratio range, is approximately 90% efficient per stage.
- Worm gears (Figure 4) consist of a non-intersecting shaft with a spiral thread that engages with and drives a toothed wheel. Worm gears are typically comprised of a bronze wheel and a steel worm. On the bronze wheel, the dominating friction is sliding friction. The bronze works as a lubricant and has a smooth surface; thus, efficiency is improved. Worm gears typically have a 5:1 to 60:1 ratio range. The efficiency of a single worm set varies with ratio and speed; this efficiency can vary from 40 to 93%.

While all these gears have their advantages, we are going to examine the hypoid compared to the worm gear.

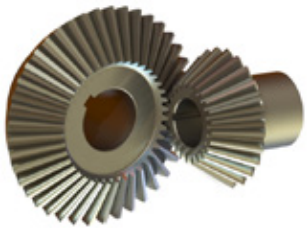


Figure 1

Figure 2

Figure 3

Figure 4

WHY WORM GEARS ARE CHOSEN

Worm gears (Figure 5) are very popular, as they are economical when it comes to their cost-to-torque ratio. Because of their ability to create high reductions in single stages, they are preferred when space is limited and large gear reductions are needed. They also can be mounted in a variety of orientations.

In addition to being compact, due to the sliding action of their teeth, worm gears are the smoothest and quietest gear systems when they are properly maintained.

However, worm gears require a bit of a wearing-in period, which delays them running at peak efficiency until this break-in time has occurred. Sliding friction is the dominating factor in their overall efficiency. The efficiency loss can be observed as heat generation. While the heat generation is taken into consideration during the design of a gear system, such as an enclosed gearing system like a gear reducer, a different gear type may generate less heat due to the gearing being higher in efficiency by nature.

Figure 5

ADVANTAGES OF HYPOID GEARS

An alternative to a worm gear is the hypoid gear. Hypoid gears may look similar to worm gears at a glance. But due to the materials used for construction and the difference in how hypoid gears interact, they therefore transmit torque differently. Hypoid gears can show an overall cost and efficiency advantage.

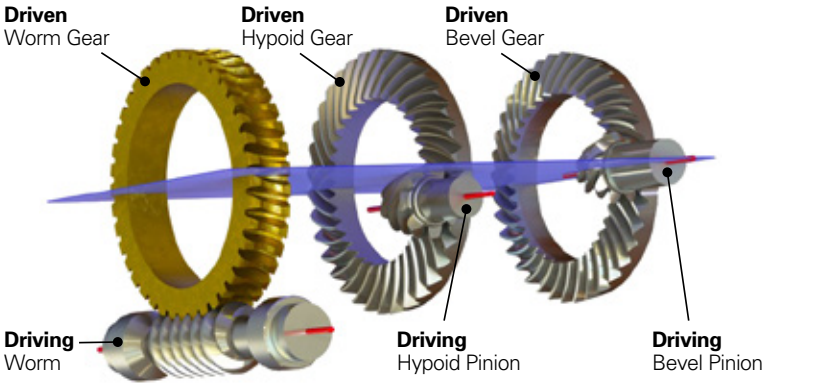
COST AND FOOTPRINT

Due to the design of the gear set — notably the way the axes of the gears intersect (Figure 6) — and the materials used, a hypoid gear set requires a smaller footprint (Figure 7) than a worm gear set to transmit the same amount of torque. This means that the hypoid gear set can fit in tighter places.

There are two main factors in the cost of either type of gear set: material and manufacturing. While the cost to manufacture a worm gear set is lower than the hypoid set, as the size grows, the materials for the worm gear set become the dominating cost, causing the total price to become greater than that of a hypoid gear set for a given performance level. The result is more torque for less cost with a hypoid gear set.

Location Difference Between Driver and Driven

Bevel/Spiral Bevel, Hypoid, and Worm Gear Types



Ratio Range: 5:1 to 60:1 (optimal); ratio range increases even greater, but efficiency varies with ratio and speed, 40% to 93%

Ratio Range: 25:1 and less (optimal); ratio range increases, 90% efficiency

Ratio Range: 10:1 and less; less ratio range, 96% efficiency

Figure 6

Figure 7

And while the initial cost of a hypoid gearbox can be higher than the price of a worm gearbox, the long-term benefits of the hypoid gearbox can outweigh the costs, as the hypoid gearbox can last longer.

EFFICIENCY

Worm gears are the most common gear type. But when it comes to efficiency, the hypoid gear set is generally better over a given ratio range and efficiency does not vary with rotational speed. The hypoid gear also has better torque density, due to the material used and the geometry of the tooth itself. The efficiency gain of the hypoid gear set over the worm gear set comes from the difference in the method of contact during the transfer of force from one gear to the other at the point of contact between teeth. By design, the contact between the gears in a worm gear set is a sliding action, whereas the contact between the gears in a hypoid gear set is primarily a rolling action with a small amount of sliding action. This difference will allow more torque transfer through a hypoid gearing set from the motor shaft to the load shaft as compared to that of a like sized worm gearing set. This means that, for a given load, the hypoid gear set runs cooler due to minimized sliding friction, increasing the opportunity of extending the life of a gearbox.

A gear reducer using hypoid gears can have nearly twice the torque capacity of a similar sized worm gear reducer. With hypoid gear sets, efficiency remains constant with varying throughput speeds and across ranges of ratios (Figure 8). Conversely, a worm gear set's efficiency varies with both ratio and speed. That is, as the speed changes, the efficiency changes. If a different ratio is used at the same speed, the efficiency will change.

Lastly, the hypoid gear set does not have the same "break-in" period as a worm gear set; a hypoid gear set operates at peak efficiency when installed.

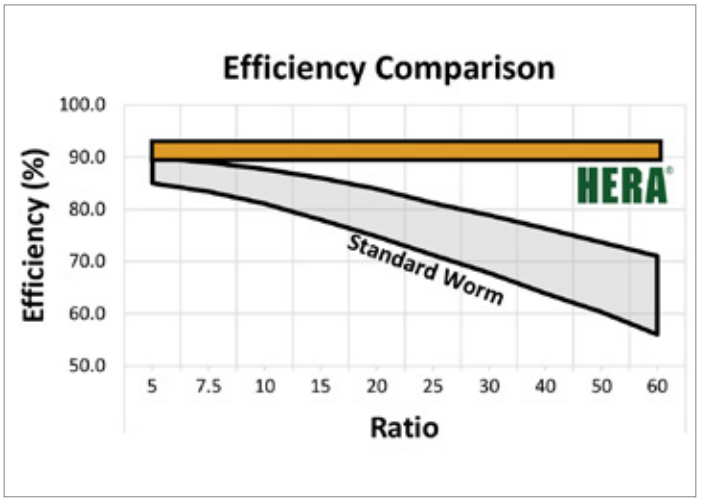


Figure 8

HYPOID GEARING IN ACTION

Regal recently worked with a national distribution warehouse for athletic shoes and apparel that was experiencing repeated problems on various conveyor ship lines with its existing worm gearboxes. The gearboxes were leaking oil due to various seal failures and subsequently dripped oil on the merchandise.

This nuisance caused maintenance personnel to shut down the lines, replace the gearboxes, and mandate drip pans in each gearbox location. On average, maintenance personnel were replacing 35 gearboxes a month, costing the warehouse over $18,500 each month in unplanned downtime (not including the cost of gearboxes and maintenance). The distribution center wanted to improve its energy efficiency while reducing the maintenance issues.

To solve this problem, Regal engineers recommended the Hub City® HERA® High Efficiency Right Angle (hypoid) gear drive. During the interchange from the competitor units to the HERA gear drives, engineers determined that the warehouse was using a 2-horsepower motor that was oversized for the application. Therefore, they recommended that the distribution center downsize to a 1½-horsepower motor. This change saves the warehouse ¼ of an amp on each motor, resulting in an annual energy savings of $80,000.

Benefits seen by this warehouse after switching from worm gearboxes to HERA gear drives included:

- Increased uptime and reduction in labor costs
- Increased torque density and efficiency allow for downsizing of units and motors
- Viton®* double-lip seals protect against leaks
- Reduced/consolidated storeroom inventory with less SKUs (HERA gear drives are dimensionally interchangeable to up to 11 sizes of worm drives)
- At least 90% efficiency (all ratios)
- Up to 40% more efficient than standard worm gearing

The HERA units (Figure 9) have been up and running with no issues for more than 28 months. The HERA gear drive solution has saved the warehouse over $300,000. The company plans to implement them on their remaining 50+ miles of conveyor lines and at other locations in North America. This type of energy savings and overall efficiency are why hypoid gear sets are well worth the investment.

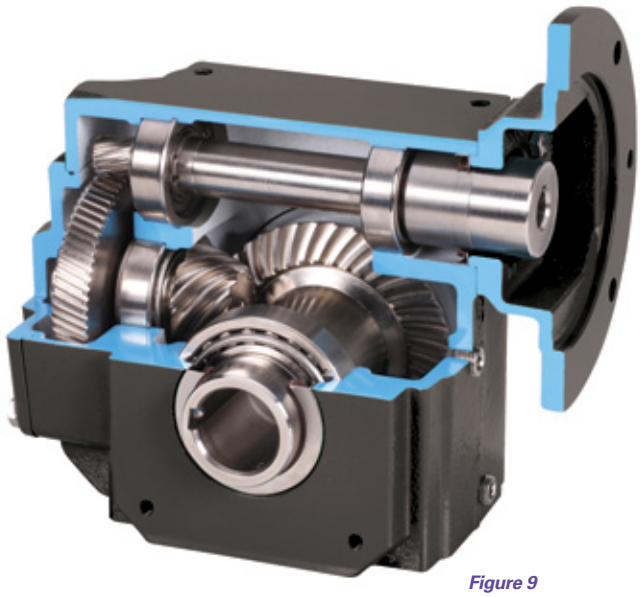


Figure 9

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ABOUT THE COMPANY

Regal Beloit Corporation (NYSE: RBC) is a global leader in the engineering and manufacturing of electric motors and controls, power generation products and power transmission components, serving customers throughout the world. We create a better tomorrow by developing and responsibly producing energy-efficient products and systems.

Our company is comprised of four operating segments: Commercial Systems, Industrial Systems, Climate Solutions and Power Transmission Solutions. Regal is headquartered in Beloit, Wisconsin, and has manufacturing, sales and service facilities worldwide. For more information, visit RegalBeloit.com.

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