Separating rack and pinion myths from reality

Rack and pinion drives are an age-old mechanism widely used for converting rotary motion into linear motion. However, myths and misconceptions abound regarding the use and application of rack and pinions in this age of servo-driven machinery. Here, we debunk some of those fallacies.

This ATLANTA rack and pinion drive system consists of a planetary reducer, ISO flanged pinion, and rack.

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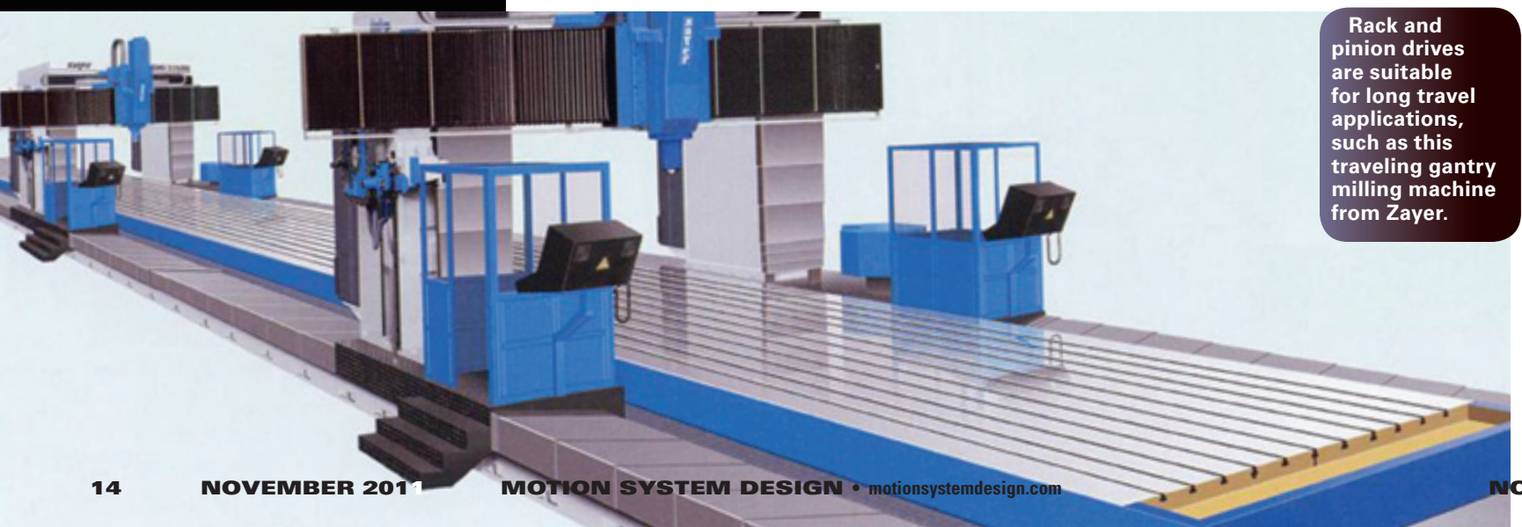
Myth: Rack and pinions are old technology that only offers low precision.

In fact, rack and pinions are an old technology, but that isn't a drawback. First, not all applications require high precision; material-handling applications, for example, can have very low accuracy requirements.

Second, advances in gear production techniques (milling, grinding, and heat treatment, for example) have dramatically improved the precision and load carrying capacity of rack and pinion drives, to the point that they are a competitive component for any linear-axis drive application.

Even rack and pinion drives with low (or zero) backlash and low (or zero) pitch error are possible.



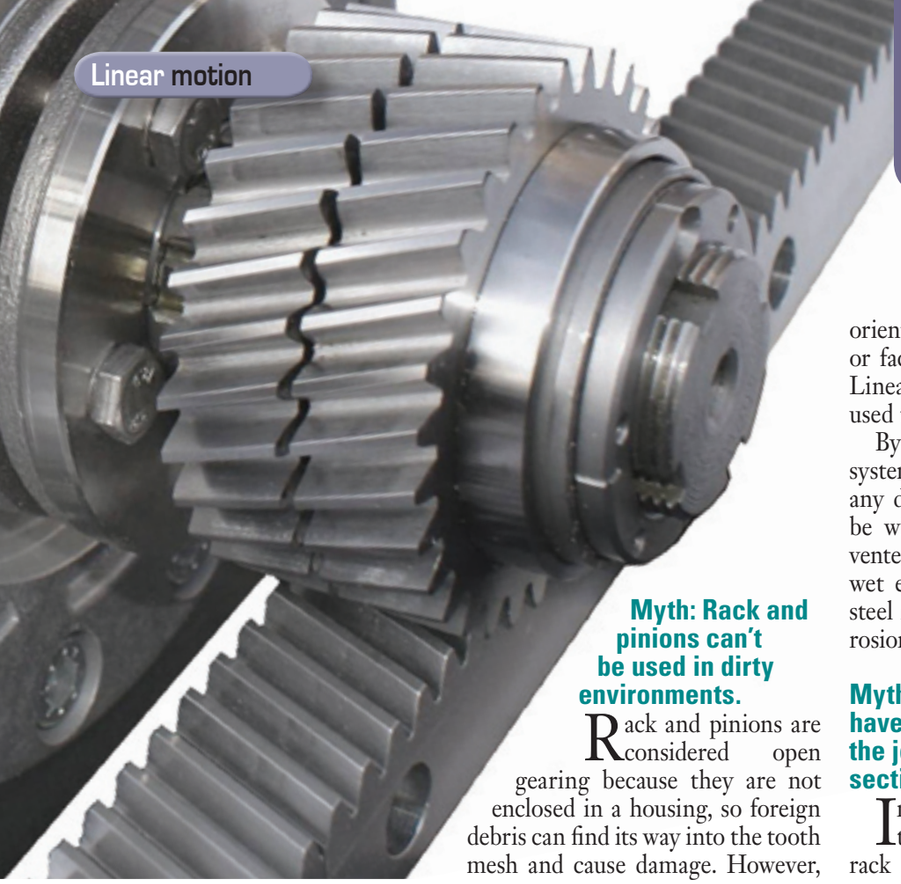
Rack and pinion drives are suitable for long travel applications, such as this traveling gantry milling machine from Zayer.

Myth: Rack and pinions have too much backlash and the only way to reduce or remove it is by pushing the pinion into the rack.

The reality is that rack and pinions have a theoretical center distance at which optimal meshing occurs. By pushing the pinion into the rack, one can reduce the backlash level — but this also degrades tooth meshing, which can cause excessive wear and binding.

The best way to reduce the backlash of a rack and pinion drive is to increase the quality of the teeth, as well as their mounting accuracy.

To completely remove the backlash of a rack and pinion drive, a split-pinion or dual-pinion drive can be used, where one pinion drives while the other removes the backlash.



A split pinion can be used to eliminate axis backlash and provide precise positioning and repeatability.

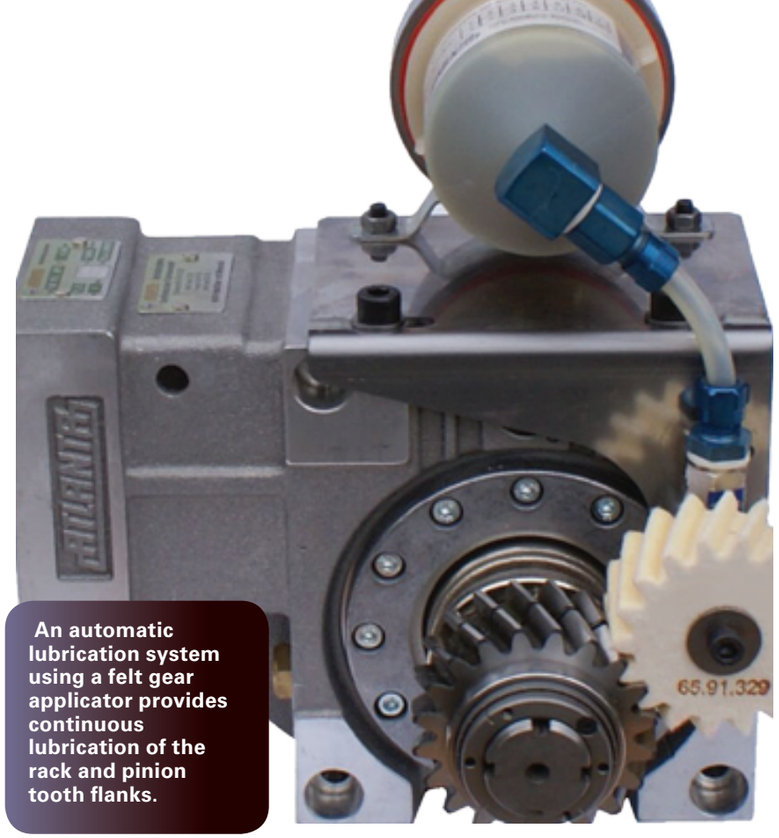
Myth: Rack and pinions can't be used in dirty environments.

Rack and pinions are considered open gearing because they are not enclosed in a housing, so foreign debris can find its way into the tooth mesh and cause damage. However, orienting the rack teeth on their side or facing down can minimize this. Linear bellows or covers can also be used to protect the drive.

By using an automatic lubrication system with a felt gear applicator, any debris on the tooth flanks can be wiped away so damage is prevented. Likewise, for washdown or wet environments, using stainless-steel rack and pinions prevents corrosion.

Myth: Rack and pinions can have excessive errors at the joint between two rack sections.

In reality, to achieve the desired travel length, multiple pieces of rack may be mounted end-to-end. During assembly, errors can be induced into the drive where the rack sections butt together. However, using a "companion" rack, which meshes between the two rack sections, can minimize this error. Otherwise, perfect rack joints with no error can be achieved by using rack assembly kits, which allow for joints to be precisely measured and any error eliminated.



An automatic lubrication system using a felt gear applicator provides continuous lubrication of the rack and pinion tooth flanks.

Myth: Rack and pinions have pitch errors that can accumulate over a long travel length.

For long axis drives, multiple pieces of rack may be mounted end-to-end to achieve the desired travel length. Although each piece of rack has an overall pitch error associated with it, this error can be controlled or even eliminated so that there is no accumulated error over the full travel length.

Depending on the quality of the rack teeth, the pitch error can be between 0.012 and 0.200 mm per meter length. It is also possible to mount racks in a predefined order to always have the total pitch error hover around zero.

Myth: Split-pinions use springs to remove the mesh backlash, which can deflect while operating.

Actually, split-pinions consist of two pinion halves — one which is fixed, and one which is axially spring-loaded. Before operating, the split-pinion is first adjusted to remove the mesh backlash; it is then preloaded to compress the spring up to the operating load of the application.

Preloading the spring ensures that the spring will **not** deflect under load during operation. In fact, when the preload is set properly, the spring will not move at all during operation. The only way the spring could deflect further is if the operating load exceeds the preload setting.

A helical rack and pinion drive from ATLANTA is suitable for myriad linear-motion applications.

Myth: Rack and pinions can't provide the same performance as ballscrews and roller-pinion drives.

In fact, ballscrews often provide adequate performance for axis drives requiring precise positioning and repeatability — by having low backlash and pitch error. Where required, zero backlash can be achieved by using preloaded nuts.

Rack and pinions can also achieve precise positioning and repeatability. By using hardened and ground tooth flanks, low backlash and pitch error can be achieved; zero backlash can be achieved by using split-pinion or dual-pinion drives.

For long and heavy axis drives, such as those found in the machine tool and aerospace industries, rack and pinions can actually outperform ballscrews, because the travel lengths of the latter can be limited by their buckling strength and whip. For high-speed applications, rack and pinion drives can also handle higher linear speeds (up to six meters per second) than ballscrews.

Roller-pinions are a system that uses rollers instead of teeth to engage a rack. These drives are touted for zero backlash because multiple rollers are engaged at one time. However, these drives require preloading of the rollers into the rack to ensure optimal meshing. This preloading can fluctuate up and down depending on the rack's mounting accuracy. If the preload is lost, backlash can develop; if the preload is excessive, the roller-pinion can develop vibration and noise, and lead to premature failure.

As mentioned, rack and pinion drives can achieve zero backlash by use of a split-pinion or dual-pinion to preload the axis. The preload is set either mechanically (split-pinion) or electrically (dual-pinion) and is always present, independent of the mounting accuracy of the rack. In addition, for high-load applications, rack and pinion drives can outperform roller-pinion drives, as the latter can exhibit lower load capacity and stiffness.

Myth: Rack and pinion uses are limited.

No — rack and pinions can be used on any machine requiring conversion of rotary motion to linear motion. From simple, low-accuracy applications to the most demanding high-precision tasks, they can be selected and applied to achieve the desired axis performance without compromises.

Typical applications for rack and pinions include, but are not limited to: CNC routers, pick-and-place robots, traveling gantries, material handling, automation, machine tool, aerospace, woodworking, stir friction welding, carbon fiber placement and seventh-axis robotic slides.

For more information, call (800) 505-1715 or visit atlantadrives.com.