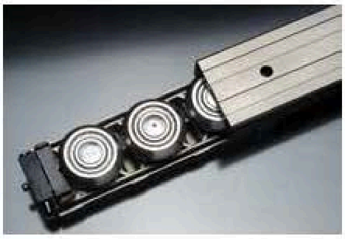
TECH TRENDS

ROLLON: Managing Misalignment in Linear Motion Systems

Of all the factors that contribute to the premature failure of linear bearings, misalignment ranks near the top of the list. Here's how to cope without breaking the bank.

When design engineers evaluate linear bearings, they always ask about performance attributes such as speed, load capacity and lifecycle. Then they want to know the price. It's rare, however, that they ask about the bearing's sensitivity to misalignment. And that's a big mistake, because misalignment represents one of the leading causes of premature linear bearing wear and failure. Linear bearings that should last for years based on expected life calculations can quit after a just few months if they are not aligned to the geometric tolerances they require to run smoothly. Usually, alignment problems begin with the design and preparation of the machine frame itself. It may not be flat, straight or parallel enough for a bearing to mounted properly. For example, mounting surfaces may have one or more high spots that will read through to the installed bearing rails. Or the frame design may make it difficult to mount bearing rails parallel to one another in the horizontal axis, vertical axis or both. Whatever the type of misalignment, the result is uneven loading of the bearing's rolling elements and raceway surfaces, including excessive point loads. These uneven loads typically cause wear in the form of pitting. Just as a pothole in the road starts small and then grows as more cars drive over it, pits on the rolling element and raceway surfaces grow with each pass of the carriage. At some point, even before it fails catastrophically, the pitting can cause the bearing to become noisy and sluggish. By shortening the working life of linear bearings, misalignment can be a significant cost driver for both the machine builder and owner. Machine builders suffer from higher warranty costs when bearings fail prematurely not to mention the less tangible cost of a damaged reputation for quality.

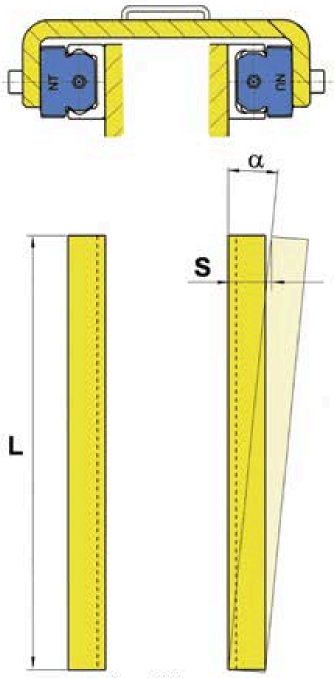


Rollon's Compact Rail system is inherently tolerant of misalignment, thanks to a rail geometry that can absorb alignment errors in one or two axes.

Machine owners, meanwhile, have to contend not just with the cost of buying and installing new bearings but also any downtime costs. Rather than incur these costs once the machine has gone into service, it's far better to deal with misalignment upfront. In general, there are two ways to do so. The hard way involves design and manufacturing procedures that attempt to eliminate misalignment altogether. The easy way accepts misalignment as a fact of life and employs linear bearings that inherently have a wide alignment tolerance. Both of these strategies have their place, but they also have drastically different cost implications.

The Hard Way

Linear guides that use recirculating balls are well-established in high precision motion applications for good reason. When properly installed and maintained, these linear guides are designed to meet the stringent positioning accuracy requirements of machine tools and other precision industrial machines. In fact, the best of these guides can be found on motion axes that offer repeatability at the micron scale. But this kind of precision doesn't come cheap. It requires machine

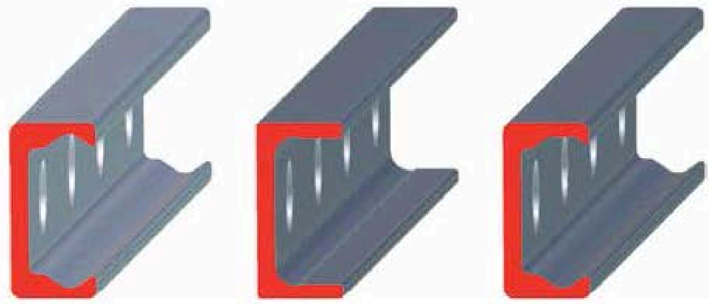


Axial Parallelism Error

builders take expensive steps to create nearly perfect mounting surfaces for linear guides. Some ultrahigh precision guides, for example, call for mounting surfaces that are straight, flat and parallel within a few tenthousandths of an inch. This process of eliminating misalignment starts when the machine is still on the drawing board. To accommodate ultra-high precision guides, design engineers will often have to specify pricey frame materials and fabrication methods that will facilitate the creation of flat, straight, parallel mounting surfaces. Typically, the required geometric tolerances will call for precision grinding and lapping operations whose cost rises exponentially with the length of the linear

to be continued

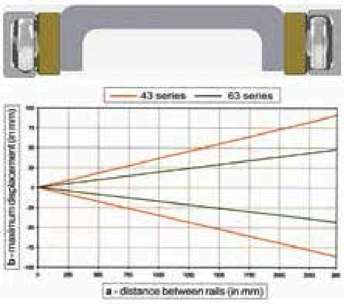
axis. What's more, misalignment can also result from deflections of the mounting surface when loaded. So ultra-high precision guides may also need engineers to beef up parts of the machine frame in order to provide linear guides with a mounting surface that is rigid enough to prevent deflection. Steps to combat misalignment also take place on the assembly floor. Assemblers often have to pull linear guides into alignment inch by inch, using custom fixtures, finicky bolt adjustments and shims. This process is nothing new for many machine builders, but it is time-consuming and expensive. And like machining, costs rise with the length of the axis.



The Compact Rail system offers three different rail profiles, which can be combined to compensate for different types of misalignment.

The Easy Way

The other broad strategy for dealing with misalignment is to live with it by choosing linear bearings that can self-align. In contrast to recirculating ball systems, another type of linear bearing feature large rolling elements, rail profiles that give the rolling elements some wiggle room and a simple preload adjustment that enable equal loading of all rolling elements. The Compact Rail System from Rollon is a prime example of this misalignment-tolerant design. Its rollers have enough rotational and lateral freedom within the raceways to offset even large misalignments in all axes. Whereas ultrahigh precision guides measure acceptable misalignment in arc minutes and microns, the Compact Rail system measures it in degrees and mm. For example, Compact Rail rollers can rotate up to 2 degrees relative to the rail without affecting functionality or increasing wear. This rotational freedom allows the system to accommodate a 20 mm difference in rail height when the distance between rails is 500 mm. Likewise, the roller's ability to translate laterally allows it to adjust to parallelism problems in the horizontal axis that is, when rails toe in or toe out. The largest Compact Rail size, for example, can adjust to displacements up to 3.9 mm over a 4080 mm rail length. Finally, because the elements are so large and can move within the raceway, they can also adjust to localized variations caused by high spots in mounting surfaces or by a less than exacting assembly process. For machine builders, the benefits of a self-aligning system come down to design freedom and cost reduction. When the condition of the bearing mounting surface becomes less critical, it is easier to design all or part of a machine frame using lower cost materials and fabrication methods. Compact Rail, for instance, has been directly mounted to sheet metal, a surface that would be too compliant for conventional linear guides. Gone too are the expensive grinding of mounting surfaces and the fussy assembly methods.



Alignment Errors In Two Planes
Rollon's K and U Rails work together to absorb alignment errors in two planes. The K Rail geometry gives the roller a rotational freedom that offsets differences in rail height, while the U Rail's flat raceways allow lateral freedom to offset parallelism errors in the horizontal plane. The system will tolerate significant misalignment (see graph) without an effect on wear or longevity.

Which Way?

When comparing the two approaches to misalignment, eliminating it or adjusting to it, keep in mind that both have their place. Some linear axes truly do need a rigid bearing with the best possible precision. In these cases, there is little choice but to spend the money on machine frame upgrades, precision grinding and careful assembly. Others axes, ones with slightly lower precision and accuracy requirements, will be better served by a more compliant guide that can align itself to imperfect mounting surfaces. Costs in these cases will be lower. What machine builders sometimes fail to realize is that these two approaches are complementary.

Many machines will have linear axes with different accuracy and precision requirements. Consider machine tools, for example. The spindle may need the most accurate linear motion system money can buy, while the tool changer and door do not. All too often, however, the same type of precision bearing that is required for one part of the machine will, by default, be used throughout all or most of the machine, driving up costs unnecessarily. A better way to go is to pick the best linear bearing for each axis individually. And whenever a self-aligning style will meet the accuracy requirements for a given axis, it will save money.

For more information:
Rollon India Pvt. Ltd.
1st floor, Regus Gem Business Centre
26/1 Hosur road, Bommanahalli
Bangalore 560068, INDIA
Tel: +91 80 67027066, Fax: +91 80 67027004
Email: info@rollonindia.in
Website: www.rollonindia.in