MOVING DOWN TO MICRON ACCURACY

As a specialist in bearings and positioning systems, PM (formerly PM-Bearings) develops high-precision cross roller guides. These bearings offer extremely smooth and accurate movement, as well as a high level of stiffness. This requires special measures in the design and manufacture for preventing cage creep and applying the correct pre-tension.

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In cross roller guides (Figure 1), rollers are positioned crosswise so that they can receive loads from above and below, and from the sides. The rollers move between two sharpened V-shaped grooves, with a cage holding the rollers in place. The cage prevents the rollers from making contact with each other, avoiding unnecessary friction and wear between these surfaces. The cage also makes assembly easier and keeps the rollers in place.

Depending on the application, different types of cages can be used. The variation can be in the type of material, e.g. POM (polyoxymethylene), PEEK (polyether ether ketone), brass, steel, stainless steel, aluminium, etc., but also in the pitch between the rollers. The shorter the pitch, the more rolls fit into a certain cage length, which in turn results in a higher stiffness and load-bearing capacity.

Anti-cage creep

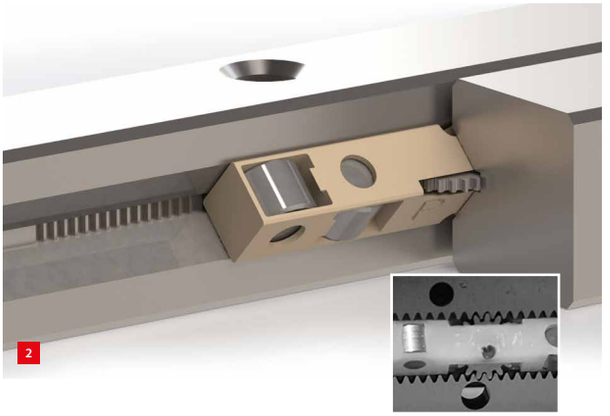
A common problem with cross roller guides is the cage slipping out of position between the guides. This phenomenon is called cage creep and over time it results in the cage colliding with the end screw attached to the end of the rail. This can result in damage or rolls exhibiting increased dragging/sliding, which in turn can result in extra heat generation and more resistance. As such, the cross roller guides end up with a shorter lifespan.

To prevent cage creep, there are various cage types available equipped with a gear in the middle; Figure 2 shows an anti-cage creep solution. The gear wheel runs over an integrated gear rack incorporated in the bottom of the V-groove. There are several options available here for different applications. A brass rack or a stainless steel/gold-plated one can be glued (possibly using a vacuum glue) into the freewheel, the lowest point of the V-groove.

For special vacuum applications, there is the option of integrating a gear rack into the guide using electrochemical machining. This process is a contactless operation that doesn't add any heat or tension to the material.

Cross roller guides vs. monorail

A frequently used product for positioning applications is the monorail or linear motor guide. One of the advantages of the monorail is that the length of the rail determines the maximum stroke of the carriage. The disadvantage, however, is that the balls go in and out of pre-tension due to the re-circulating movement. This causes vibrations, while in a cross roller guide rollers are in a constant state of pre-tension, so there are no vibrations. This constant pre-tension combined with the high accuracy of the guides and rollers ensures an extremely smooth and precise movement.



1 *A set of linear cross roller guides.*

2 *An anti-cage creep solution with a gear in the middle of the cage. The inset shows the rack over which the gear wheel runs.*

The length of the rail in combination with the length of the cage, however, limits the stroke of the cross roller guide. If that is what's required or is permissible, then cross roller guides offer major advantages over monorails. The use of rollers (line contact) instead of balls (point contact) allows for higher loads and also provides more stiffness. Cross-roller guides are most often used in the high-accuracy segment, where smooth movement and low frictional resistance are required. Whether or not the cross roller guides are used in combination with a high load, positioning at micron or submicron level is possible.

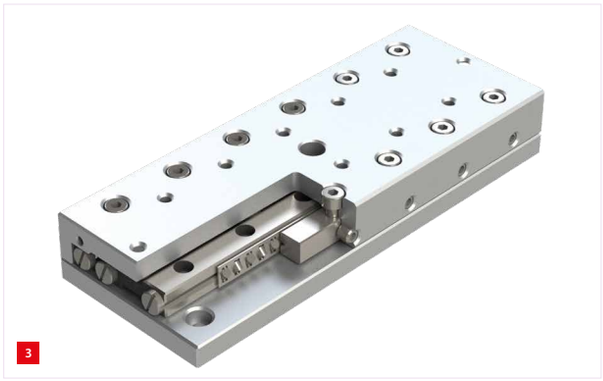
Cross roller guides vs. air bearings

As part of precision-produced positioning systems, cross-bearing guides can match the accuracy of air bearings. Air bearings are known for their extremely smooth movement and high load-bearing capacity, but are not on a par with mechanical bearings when it comes to stiffness. Air bearings are also more complicated to use and are, as a rule, more expensive to buy.

Another factor that makes cross roller guides even more attractive to use are their mirror-ground running surfaces that minimise the resistance between the roller and the running surfaces. This option is known as 'super finish' (SF). Due to the low surface roughness (R_a < 0.05 µm) of the SF option compared to the standard surface roughness of the V-groove (R_a < 0.15 µm), these cross roller guides are ideal in microscope tables, imaging systems in life sciences and lithography systems in the semiconductor industry.

Pre-tension

In addition to the individual components, the assembly mode of cross roller guides also helps achieve submicron accuracy. Pre-tension can be applied to a cross roller bearing by tightening a screw against the guide using a specific moment, as happens at a roller table that has cross roller guides inserted (Figure 3). This requires considerable professional skill however. Applying too much pre-tension can result in small indentations in the rollers in the V-groove, which reduces movement accuracy. If there is not enough pre-tension, play will occur. When a cross roller guide has different pre-tension levels, the running resistance during an inward stroke will differ from that of an outgoing stroke, for instance.



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3 *Roller table with built-in cross roller guides (partly uncovered). Applying pre-tension to a cross roller bearing requires considerable professional skill.*

4 *PMMR micro-roller table.*

Another way to apply the pre-tension bias is to 'sort' all parts, i.e. to match their individual dimensions to the cage they have to fit in. One example of this is the micro-roller table type PMMR (Figure 4). In the table part, the V-groove is accurately ground with a deviation in the parallelism from groove to groove smaller than one micron. The centre guide also has the same degree of parallelism, better than 1 µm on both grooves. By matching these two parts and then using a roll grading (roll-cage fit) of 0.5 µm, the pre-tension can be applied very accurately and evenly.

Some of these miniature tables with rollers are used in pick & place modules for the semiconductor industry, e.g. for SMT machines. Surgical robots like the Da Vinci also use these tables to make very fine and smooth movements. Service life and reliability are very importance in these cases.

From bearings to positioning systems

Based in Dedemsvaart, the Netherlands, PM (formerly PM-Bearings) has been producing and supplying bearings to international players in the semiconductor, optical and medical industries, amongst others, for more than 50 years. One of the main reasons behind the company's name change from PM-Bearings to PM last December was to avoid the assumption that the company only produces bearings.

With its extensive knowledge of the production of high-precision guides and all associated components, PM decided in the late nineties to also enter the market for complete positioning systems. The integration of linear guides, but also the use of rotation and gonio bearings – all of which are produced in-house – gives PM a competitive advantage. In addition to manufacturing catalogue products, PM also develops and manufactures many client- and application-specific guides and roller tables.

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