

Solving the Problems of Long-Stroke Linear Motion

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For most linear motion applications, conventional belt- or screw-driven systems work well. However, issues can arise when longer linear distances are required.

Belt-driven systems are an obvious choice when long linear movements are required. These relatively straightforward systems use pulley drives to create tension along the belt, and they can be brought quickly up to high speeds. However, as these systems reach longer strokes, issues can arise with sagging belts. Tension cannot be maintained across the length of the system.

There is also inherently a lot of give in the system from the rubber or plastic belts themselves. This flexibility across the length of the system can cause vibration or springing, which creates a whipping effect on the carriage. If a specific process cannot handle this, a screw-driven system may be a better option. Screw-driven systems have a fixed mechanical element that ensures complete control of the carriage at all times with exact stopping and positioning.

Safety is another advantage of screw-driven systems. Belt-driven systems are less safe because of the possibility of the belt breaking. Such a fault would be uncontrolled and, in vertical applications, the load could fall and damage machinery or even personnel. A screw-driven system doesn't have that problem. Even upon failure, a screw-driven system would stop the load from falling and ensure safety.

Historically, the issue with screw-driven systems has been the difficulty in reaching longer stroke lengths. Screw-driven systems can commonly be provided in lengths of up to 6 meters using pairs of bearing blocks to support the screw and stop any whipping effect at higher rotation speeds. Even at lower speeds, longer screws need support against bending caused by their own weight. This bearing block support system traditionally consists of pairs of blocks connected with a rod or wire. The pairs move together along the linear motion system.

When a system requires a longer stroke, more bearing block pairs can be added to support the screw at regular divisions along its length. Having up to three or even four pairs working together can be practical, but connecting the rods or wires between the blocks becomes difficult beyond this number.

Longer Strokes

The first challenge to achieving a longer stroke is to create a system that can offer more support points for the longer screw. One solution is to do away with the connected system for the blocks and, instead, use a system in which the blocks can collapse into each other and separate out when required. Once the blocks reach their set position, they stay there to guide and support the screw. In such a system, 10, 12 or even 13 support points can be realized with bearing block pairs. This support system for the ballscrew or lead screw can enable long travel distances without bending or whipping.

To go beyond 6 meters in length, the next challenge is to create a longer screw. However, due to restraints in the raw material available, screws are only normally produced up to 6 meters in length. So how can a stroke length of more than 10 meters be achieved? The answer lies in attaching two screws together and employing some precise manufacturing techniques.

Lead screws and ballscrews are manufactured on a rolling line, and each part may be produced with a slightly different lead deviation. To join two parts together, therefore, differences in lead deviation need to be overcome. For two screws to be successfully joined,

the highest precision ballscrews with the smallest possible deviation must be used. The ballscrews must be precisely machined, ensuring heat does not enter the part and alter the diameter or lead geometry. Even a deviation as small as 0.01 or 0.001 millimeter can create problems for the final system.

After machining, the screws are married together using a tap and hole with minimal deviation between the two leads. They are finally secured using high-strength adhesive. (Welding the screws together would again alter the geometry and create problems.)

Screw-driven systems with collapsible support block systems and precision-manufactured screws can be made in lengths of 10.8 meters or more. A system with a stroke length of 2 to 3 meters would have a maximum speed of around 4,000 rpm. Normally with a longer system, the rotational speed would have to be lowered considerably to avoid whipping. But, with additional supports, a screw-driven system up to 10 meters long can run at 4,000 rpm.

Long-Length Applications

Screw-driven systems with long stroke lengths are used in a wide range of industries to provide precise linear positioning. A good example is an automated welding system for metal pipe and tubing. Accurate positioning of a welding nozzle over long travel lengths is required. In applications where high-quality materials are being welded, such as titanium, the operation is carried out in a vacuum to avoid oxidization of the metal.

Many applications in the automotive industry require long travel lengths. For example, six-axis robots are often mounted to long-stroke linear actuators for welding or machine tending operations. Although speed may not be a critical factor for transporting robot arms, long length and very accurate positioning are required.

The manufacture of optical cable is a high-speed, continuous operation that cannot be stopped without jeopardizing the quality of the fibers being produced. The cables are spooled onto large reels. When one reel is full, it must be replaced quickly to minimize the loss of product. Precision and speed are vital to process efficiency. Long screw-driven systems can offer both in this application, along with the capability of handling the heavy load of the reels.

Any application requiring the movement of heavy equipment in the vertical plane benefits from the rigidity and fail-safe functionality of a linear screw. In the aircraft industry, for example, high precision cameras are moved up and down. Screws carry the heavy weight securely and precisely. In such applications, special ball guide systems with large diameter balls are used to take up the dynamic load moment.

Improvements to Existing Systems

In many long-length linear motion applications, the ballscrew is left completely open. There are two common issues with such systems: Either the system cannot operate at the desired speed, or the system is difficult to maintain, since the open screw attracts dust and debris, requiring regular cleaning to avoid premature failure of the ball nut.

In such applications, the additional support provided by the stacked bearing block configuration means the screw can be operated at a much higher speed. Cleaning and reliability issues can be resolved using a covered, sealed system that protects the screw and offers significant reductions in maintenance requirements. The enclosed screw is protected from ingress of dust and debris and, without regular cleaning, can maintain optimum performance and reliability.

In such a system, the carriage can be equipped with drilled channels and connected with a grease nipple. This enables lubrication from a single point without having to open the casing. Because the unit never has to be opened, limited amounts of dust or water can penetrate the system. It's protected even in the dirtiest environments.

Images & Captions:

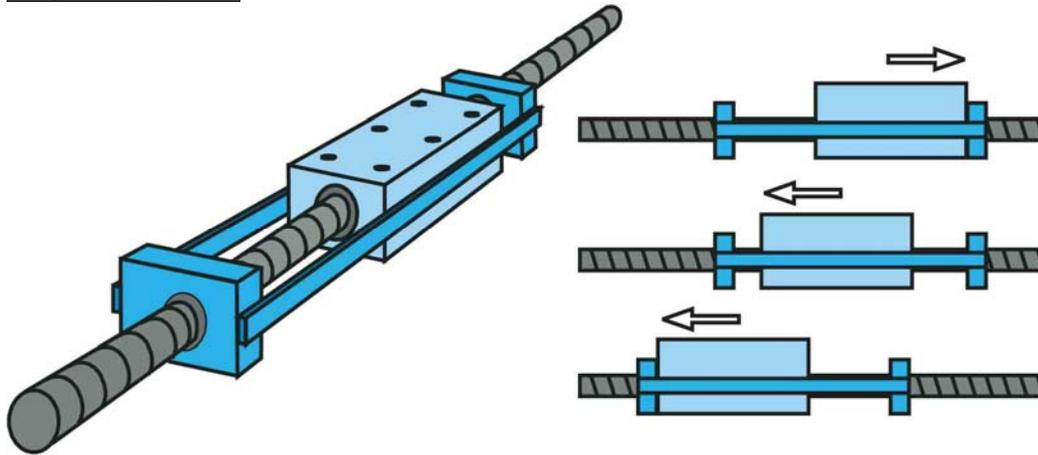


Fig 1: Bearing block support systems traditionally consist of pairs of blocks connected via rod or wire. The pairs move together along the linear system.

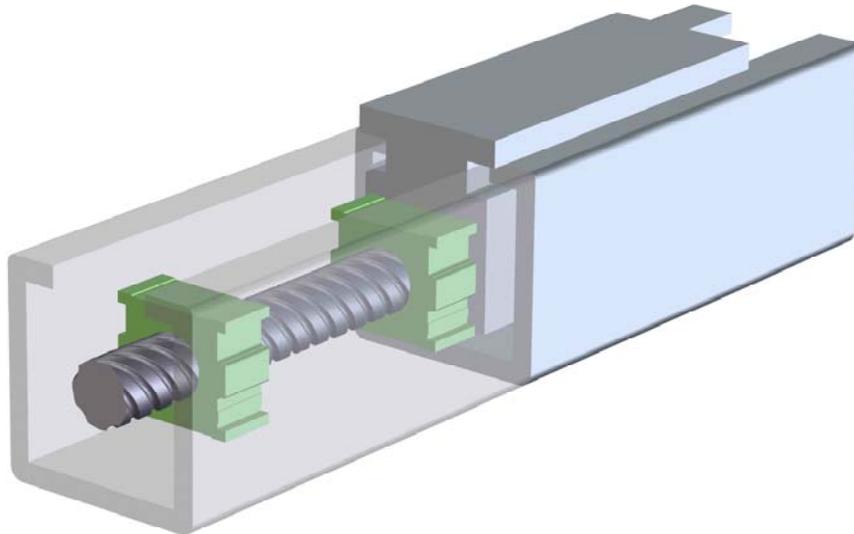


Fig 2: Modular support system from Thomson with interlocking movable block pairs



Fig 3: Enclosed screws are protected against the ingress of dust and debris in Thomson linear drive systems.



M75 Belt Image: Thomson's linear rodless actuator slides provide guided linear motion through a belt drive and saddle that rides along the top of the actuator to carry the load.