

A Comparison of DC Linear Actuators with DC Linear Motors

Factory automation and robotic application engineers are often faced with the challenge of requiring fast, accurate and powerful linear actuation within a small allocated volume. The two most commonly available technologies are rotary DC motor driven actuators and linear DC motor actuators. There are of course advantages and disadvantages with all technologies and they are sometimes easily overlooked. This short summary contains some common considerations.

Linear Motors

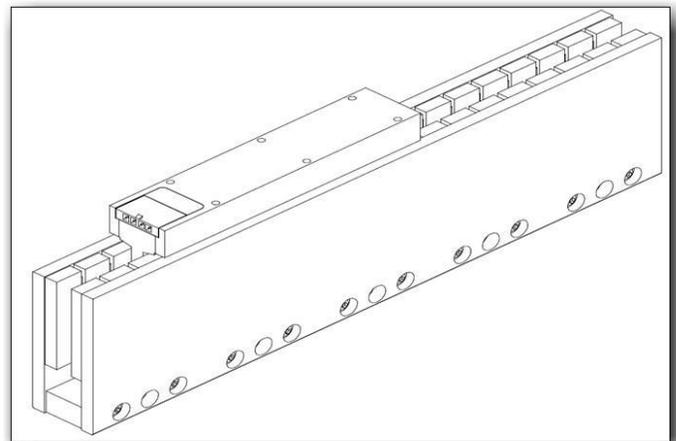
An easy way to think of a linear DC motor is to take a standard DC motor and lay it out flat. For example: A line of motor stator coils over or along which is passed the permanent magnet sliding actuator. They can also be manufactured as a rail of magnets with a moving coil. These can be flat or circular shapes.

Advantages:

- The main advantage of a DC linear motor is speed. Smaller and high quality units can achieve outstanding acceleration rates.
- The other advantage is operational life. Because there is no gearing and the only friction points are the required linear guides, the lifespan is therefore relatively long.

Disadvantages:

- Linear DC motors have a very low force or in particular a very low speed force gradient compared with DC linear Actuators. Of particular importance is the need to compare the same figure. Manufacturers from different parts of the globe often use a completely different standpoint from which to select catalogue ratings related to force. Peak force, stall force, rated force, holding force, back driving force to name a few. The most comprehensive test is to use a force gradient. This can be calculated or informative companies will supply you with the figure representing meters per second per Newton (m/s/N). The gradient of this speed force line represents how much the unit slows down for every Newton of load that is applied and this is a true test of its strength.
- The second disadvantage is current draw. Because linear motors are a direct drive solution and there is a higher level of current rise with the required feed force, a geared solution will be proportionally lower.



Common linear motor design

Linear Actuators

In this comparison we are looking at DC motor driven linear actuators only. These are supplied in many forms from inline OEM style units to off-the-shelf self-contained units. In the interest of fairness we should also do a quick comparison within this sub category.



OEM Linear actuator

OEM Units

These are units that are designed specifically for integration into a product being developed from the ground up, where the actuator section of the unit becomes part of the product itself. This is done in the interest of keeping the overall size and weight to a minimum. This could be a system as simple as a DC motor driving a threaded section using an actuation nut or a more robust design of an integrated ball screw, thrust block, DC motor, gearhead and encoder assembly.

Self-contained Units

These are commonly available linear actuators that typically have a DC motor mounted beside the threaded section that is driven by a belt and pulley. The threaded or spindle section is contained in a tube. A fixed nut is connected to an overtube that pushes an actuation rod in and out. These are bolt on units typically used on hospital beds and low duty cycle applications that seem at first glance to be a good solution, however they are bulky and inefficient compared to an OEM style spindle drive. The low cost DC motors commonly used in this style of actuator can have quite high radial load applied from the belt and pulley mechanism. This can result in pre-mature failure of the motor bearings.



Self-contained DC linear actuator

Because this application note is written for automation and robotic design engineers we can assume the OEM style will be far more applicable in terms of space, power, efficiency and reliability so we will make a comparison of advantages and disadvantages between the OEM style actuators and linear motors.

Advantages:

- DC motor driven actuators can produce much higher forces per volume than linear motors.
- The nature of the thread or spindle section gives both self-locking and free running options.
- High efficiency is possible. Particularly with the recent advances in ceramic and other high grade running materials.

- Controllability is very easy with the simple mounting of standard encoders on the rear of the motor. Combined with the gearing ratio and the thread pitch this gives a very high positioning resolution from standard motor position controllers.
- Cost: One must compare the additional system components required for the same overall result. Linear encoders, linear guide rail, limit switches etc. are typically required with linear motors. Much of this additional cost can be avoided with integrated OEM style units that do not require all of these add-ons.

Disadvantages

- The main disadvantage of a DC linear actuator over a linear motor is speed. Top speeds of around 180 to 200mm/s are typical.
- The second main disadvantage is integration. In order to reduce the overall machine size and by design, the fixation of the spindle nut is part of the application load itself and as such a certain level of system design and integration is required from the customer.

Summary

This short document touches only on some of the issues considered in complex design projects and the detail needs to be thoroughly investigated before the purchase of a product. This highlights the importance of dealing with a supplier with worldwide representation, data sheets that you can trust and a willingness to customize the product for the application requirements.

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