EDRIVE ACTUATORS

Measure While You Press
Force Feedback in Linear Actuators

Introduction

Electric Linear Actuators

Successful automation processes that use linear actuators may benefit from incorporating force feedback into the control loop. In fact, most motion specialists are familiar with the concept of electrical feedback or pressure feedback from forces applied in electrical or hydraulic systems.

Monitoring force feedback can improve process control, help maintain consistent product quality, and protect capital equipment. The focus here will be on force feedback in electric actuators, common methods of measuring and monitoring forces applied to electric linear actuators and comparing the merits of each method.

Is it better to calculate motor torque using motor current values and manufacturer's constants or measure electric signals from load cell transducers that are mounted where loads are applied? While open loop systems may be simpler and require a smaller initial investment, closed loop systems offer improved accuracy for controlling industrial processes.

Designers who wish to switch from monitoring motor current in open loop systems to measuring electrical output signals generated by load cells will find that it is easy to retrofit rod end load cells onto electric cylinders. In doing this they will need to consider the alignment and fit of the actuator once the rod end load cell is added to the assembly.

When specifying the initial system, designers may benefit from selecting electric actuators with internal load cells. This option is a practical solution that provides optimum alignment, protection of load cell sensors, and streamlines the path of cables from actuator to controls.

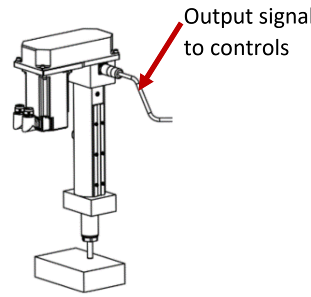
Why is it Important to Monitor Force Feedback?

Process Control

When it comes to industrial automation, force feedback can literally make or break a product. Applications often require actuators to press or hold with a prescribed force. If the desired force is not exerted, the set process may not be successfully completed. For example, in injection molding applications linear actuators are often used as clamping devices, holding the platens together. Accurate force feedback can ensure that the targeted forces are achieved (and not exceeded). Failure to meet the required force can result in out-of-tolerance components. In this example, the prescribed clamping force must be confirmed prior to the shot of plastic material being injected into the cavity.

Actuators are used to clamp platens

Maintain Consistent Quality



Combining force feedback with statistical process control techniques enables operators to identify when a process is trending away from nominal and take corrective actions.

Consider a process that must maintain a prescribed force to press fit a pin. A force value that is abnormal or trending away from nominal could be indicative of a process trending toward out-of-tolerance. Force feedback enables operators monitoring this variance to pre-emptively make corrections to the process.

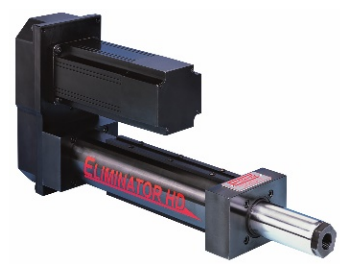
Actuators are used to press fit pins

Protect Capital Equipment

In certain applications protection of production machinery can be a concern, particularly in high load applications where process failure can result in irreparable damage to equipment, injury, and costly periods of down time. With the availability of actuators that can exert forces up to 100,000 lbs., it is easy to understand why overload protection is necessary. Monitoring force feedback can help to prevent equipment and product damage.

Common Methods of Monitoring Force

Using Motor Current to Monitor Output Load Values



A common method of determining the applied force in a screw-driven linear actuator is to calculate it based on the input current of the motor. This is a cost effective and convenient method because no additional equipment is typically needed, but it does have limitations.

Servo Motor Mounted to Electric Actuator

Using this method to determine the force exerted by an actuator begins with the calculation of the motor output torque. This value is estimated* using the motor's torque constant and the current drawn by the motor using the formula below:

K_t*:	in-lb / Amp	Torque Constant
T:	in-lb	Motor Torque
A:	Amps	Current

$T = K_t \bullet A$

*K_t values published by motor manufacturers may vary by ±10%

Once the motor's output torque has been determined, the actuator's output force becomes a function of the following:

T:	in-lb	Motor Torque
L:	in	Screw Lead
E_f:	%	Screw Efficiency

$$\text{Driving Force} = (2\pi \bullet T \bullet E_f) / L$$

Note that this calculation assumes that the motor is directly coupled to the power screw. If the motor is connected to the power screw via gear reduction from a belt or gearbox then one must account for any mechanical advantage, as well as the corresponding loss of efficiency.

While it may be less costly and more convenient to use motor current to extrapolate the force exerted by an actuator, the result must be considered only an estimate since it is calculated from theoretical values. For example, the motor constant values may vary by as much ±10% of published values. Additionally, the assumed efficiency of the actuator screw may vary over time due to wear, misalignment and other factors.

<u>Using Load Cell Transducers to Monitor Output Load Values</u>

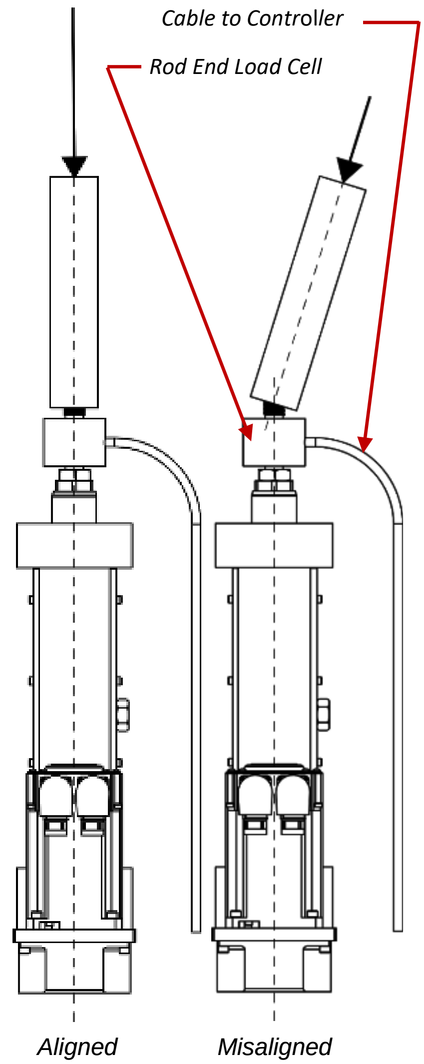
Using load cells to determine the applied force in screw-driven linear actuators is the preferred method because it measures loads at the actuator where they are applied.

Load cells placed directly in line with applied forces convert minute material deformities into electrical output signals whose values are proportional to the actual applied load. When loads are measured at the point of application, accuracy may be as great as ±1%.

Rod end load cells are a common type of load cell which can easily be retrofitted to actuators. As their name suggests, they are intended to be threaded onto the rod end of actuators. When incorporating these load cells, attention must be given to the alignment of the load cell and to the applied force. For accurate measurement, forces must be applied axially to the load cell. Any off-axis or transverse forces will cause the load cell to report incorrect readings. If the misalignment is severe, permanent damage to equipment is likely to occur.

Since rod end load cells are typically installed between the connection of the actuator rod and the applicable tooling, accommodations must be made to accept this added length in the system. In some instances, these accommodations or design changes may not be possible. In addition, the cable to the controller must be secured throughout the full range of motion. Long cables are not ideal even when cable ties are used to bundle them because they can become entangled and interfere in the automated movement of the system.

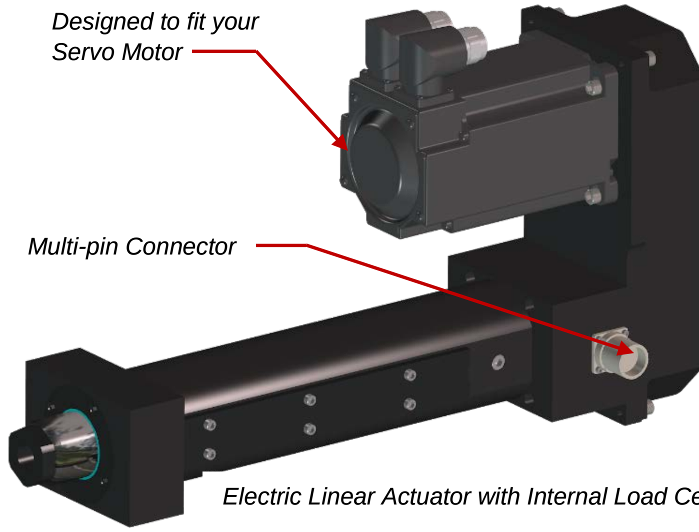
In closed loop systems feedback from the load cells is processed by the controller to make continuous adjustments to the current supplied to the motor, ensuring that the correct force is being exerted by the actuator. Closed loop force feedback systems can be as accurate as ± 1% of the actual applied force. This is a vast improvement over the accuracy of loads estimated using extrapolated values because it is based on the measurement of the actual forces.



Internal Load Cell Option

EDrive is proud to offer actuators with internal load cells capable of measuring forces in both directions. Actuators with internal load cells are unique to EDrive and deliver distinct advantages over alternative force monitoring options.

By design, EDrive's load cell registers only those forces that are axially aligned with the actuator; therefore, transverse forces applied to the rod end will not be transmitted to the load cell. This ensures the highest degree of accuracy.



Electric Linear Actuator with Internal Load Cell

Integrating the load cell into the actuator is also significantly more practical. All load cell actuators from EDrive come with an industry standard multi-pin connector which is located on the body of the actuator. This eliminates problems associated with dynamic cable management typically seen when using rod end load cells. It also ensures a more compact unit and protects the load cell from the environment.

EDrive is the only manufacturer offering internal load cells capable of bi-directional force feedback that allow users to measure forces while extending and retracting the actuator. This feature is available on Eliminator Series actuators with rated thrust capacities ranging from 1,000 lbs. to 100,000 lbs. For more information check out the HDL and STL actuators online at www.edriveactuators.com

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