White Paper

CURTISS-WRIGHT

Technology Transfer Brings New Life to Electric Control Valve Actuation

EXLAR®

Exlar® electric roller screw linear actuators, rotary servo motors, and integrated control solutions are used for motion control for a broad range of applications. Our roller screw technology provides an efficient electro-mechanical replacement for your hydraulic or pneumatic cylinders with forces exceeding 40,000 lbf, and linear speeds which surpass 60 inches per second. www.exlar.com

Exlar® actuators are a brand of Curtiss-Wright Sensors and Controls Division.

Technology Transfer Brings New Life to Electric Control Valve Actuation

By Barb Boynton, Curtiss-Wright/Exlar® Actuation Solutions.

Electric actuators have long been used for general valve automation. When applied to control valves, however, limitations inherent with traditional electric technology preclude its effective use for modulation control, especially when fast response is required. Servo motor control and roller screw technology, both used for years in the motion control industry, do not suffer from the same limitations and can therefore offer a highly responsive, robust, and accurate electric solution that is well suited for demanding valve control applications.

Motor

Traditional electric actuators typically use single or three-phase induction motors as the driving force. While suitable for on-off applications, they fall short for continuous control needs. The problem with this motor design is that the actuator's ability to start, stop, and change direction is limited by motor temperature rise rather than by what is required to optimally control the process. These actuators therefore have limited duty cycles, making them unsuitable for control valves.

One way around this limitation is to use a continuous duty cycle brushless DC motor; however the mechanical side of the actuator still limits the solution in terms of speed and life.

Mechanical

In order to get the needed torque out of the motor, traditional electric actuators use a high reduction gear train such as worm gears or spur gears. [Figure 1] This high reduction severely limits the available output speed of the actuator. Additional drawbacks of this type of mechanical transmission include a relatively short useful life and low energy efficiency. For this reason, these electric actuators are slow, and not suitable for controlling rapidly changing process parameters such as pressure.

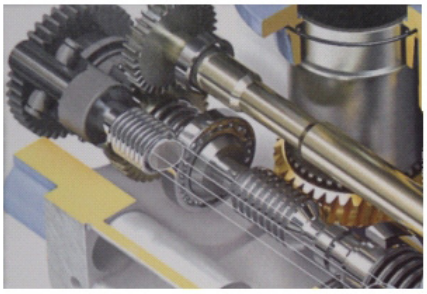

Figure 1

The limitations of traditional electric actuators have an impact on the life of the system. The most common problem is exceeding the rated duty cycle, causing the motor to burn out. Other issues include wear of the gearing. A "high end" traditional electric actuator might have a design life of only 50,000 operations.

A study done by ExxonMobil and presented in October 2012 at Coking.Com identified the following wear issues:

Major electric actuator wear areas include:

- Bearings - drive sleeve and worm shaft
- Sliding surfaces – drive sleeve splines, worm shaft splines, worm and worm gear teeth
- Motor pinion and drive gear

Failure areas:

- Circuit boards can be damaged by heat and steam
- Sensitive to vibrations
- Interlock relays have become stuck

For linear applications, an additional lead screw or ball screw assembly is needed to convert the motor's rotational motion to a linear force. Lead screws have sliding friction surfaces that cause rapid heating, and continuous operation is likely to result in a screw failure. Ball screws utilize ball bearings to provide rolling contact between the nut and the screw, providing significantly longer life and higher efficiency when compared to a lead screw. Ball screws still do not offer adequate life for high duty cycle modulating applications and their moderate force capacity results in a larger than necessary system package size.

Motion Control Technology Transfer

The motion control industry uses servo motor technology coupled with planetary roller screws for a variety of arduous applications including military environments and high cycle and speed loads. The technology offers no duty cycle limitations, response and stroke times of milliseconds and virtually no dead time making these actuators a perfect choice when electric actuation is needed for control valve applications. In fact, the combination of servo motor and planetary roller screw offers the only true electric alternative to a hydraulic cylinder in terms of force density, life, and overall durability.

The Exlar® Solution

Figure 2

Servo motor technology includes the use of a brushless motor paired with a feedback device for control of both the position and the speed of the output shaft. Depending on the type of device selected, one motor revolution is divided into as many as 3,200,000 incremental positions. The fine resolution of the feedback device results in a continuous position accuracy of roughly 0.001" when used with a 0.1" lead roller screw in a linear application. In addition to the closed loop feedback, servo motors also offer high torque to inertia ratios, 90% efficiency, and reserve power of up to 2x continuous power. Servo motors are meant to continuously change position, so duty cycles are 100% continuous. Speeds can be up to 5000 RPM providing unprecedented response time.

Not all brushless servo motors are alike. The Exlar T-LAM technology incorporated into the motor design provides a solution with 35% more motor torque in a similar package size. [Figure 2] These efficiencies are a result of the limited heat generation qualities inherent in the segmented stator design.

Mechanical

For linear applications, one of the main differences with the motion control solution is the replacement of the gear train with an inverted roller screw. A roller screw is a mechanism for converting rotary torque directly into linear motion providing the ability to carry heavy loads for thousands of hours in the most arduous conditions. The difference is in the roller screw's design for transmitting forces. Multiple threaded helical rollers are assembled in a planetary arrangement which converts a motor's rotary motion into linear movement of the shaft. [Figure 3]

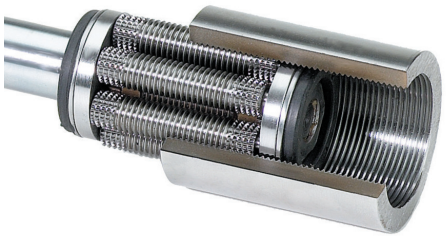

Figure 3

The design allows the motor to be wrapped directly onto the outer shell; rotating the roller screw up to the full RPM's of the motor. This allows the linear movement to be as fast as 40 inches per second; speeds unheard of in typical electric actuators.

For rotary applications, the spur or worm gear train is replaced by a planetary gearbox. [Figure 4] The load sharing attributes of multiple tooth contacts in the planetary gears provide high torque and stiffness as well as extreme long life. In addition, the balanced planetary kinematics at high speeds combined with the associated load sharing make this rotary actuator ideal for very precise control of quarter turn valves.

Life

With the cool running servo motor integrated with a roller screw or planetary gearbox, the design life of an Exlar actuator is measured in 100's of million strokes vs. thousands like typical electric actuators. In addition, the

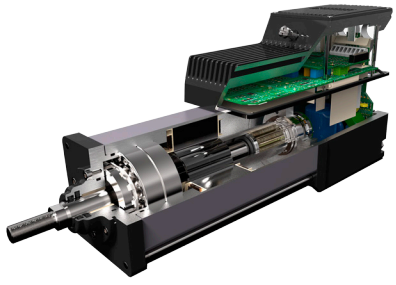

Figure 4

controls and positioner used with Exlar actuators provide closed loop feedback, eliminating the need for limit switches, torque switches or any mechanical means of feedback found in typical actuators, further extending the life.

By combining the servo motor, feedback, and roller screw or planetary gearing with a controller into a compact system, a perfect control valve electric actuator is created. Standard options include hazardous environment housings, manual override, digital communications, and additional I/O capability.

Summary

Traditional electric actuator technology has many drawbacks that limit its effectiveness for use on control valves. Successfully employed in the motion control industry for years, electric actuators based on servo motor and roller screw or planetary gear technologies eliminate these limitations allowing for a highly responsive, robust, and accurate electric actuator solution that is well suited for valve control. Curtiss-Wright has designed Exlar actuators specifically for valve control utilizing this technology. These actuator solutions accommodate a wide range of typical valve control applications, including installations in hazardous environments, and offer unheard-of flexibility and performance relative to traditional solutions.

CASE STUDY EXAMPLES

Power Utility

Steam soot blower control valves for fossil-fueled power plants modulate flow over a wide range and must also maintain downstream pressure between very close limits at high differential. Slow response rates to rapid load swings result in poor control; therefore existing electric technology could not be used. The Exlar GSX50 electric actuators utilizing servo control integrated with a roller screw provide rapid response and high accuracy. [Figure 5]

Figure 5

Pipelines

Liquid pipelines use pumps and valves to control the flow of the various refined products or natural gas liquids. They need to run 24/7 and must fail in place (last controlled position) to prevent pressure build-up. Many were originally installed using hydraulics, which incurred high cost both initially and through the life of the actuator with high maintenance issues. Pneumatic actuators were not possible due to temperature extremes and lack of clean compressed air. The Exlar® Tritex II™ linear actuators work flawlessly on these applications, providing tight control, fail in place capability, large temperature range, life in the 100's of millions of strokes and RS-485/ modbus RTU diagnostic capability. [Figure 6]

Figure 6

Drainage Vacuum System on Paper Machine

These rotary valves need fast response especially when the valve is just opening/closing to header vacuum. The Exlar® Tritex II™ rotary actuators provide accurate and repeatable vacuum level control in addition to significant energy savings.

About the Author

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