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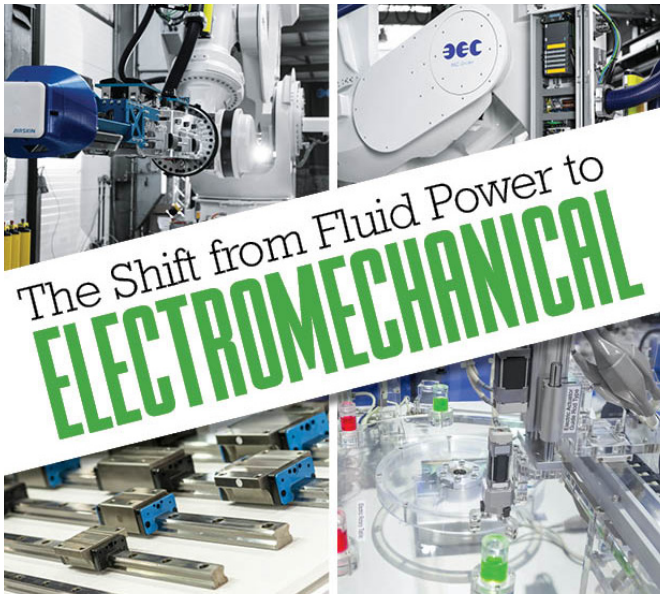
The Shift from Fluid Power to ELECTROMECHANICAL



The Shift from Fluid Power to Electromechanical Technologies

HYDRAULIC AND PNEUMATIC SYSTEMS remain viable methods of motion control in many applications. However, there are a growing number of industrial and mobile applications which are moving from fluid power to electromechanical solutions — or sometimes a hybrid of the two.

This is enabling efficiency and productivity gains, both of which have become increasingly important due to continued electrification and automation of machinery.

In this eBook you'll find articles discussing why the technology shift is happening, how to determine which motion control solution to use as well as application examples to help design teams better determine the best option for their next project.

Sara Jensen,
Executive Editor,
Power & Motion

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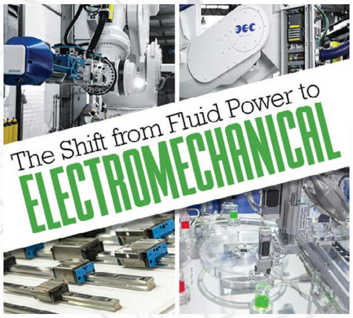


Tolomatic

CHAPTER 1:

Why Electric Actuators are Replacing Hydraulics

SARA JENSEN, Executive Editor, *Power & Motion*

The precision, repeatability and lower total cost of ownership associated with electric actuators is driving their use over hydraulics in many industrial applications.

Hydraulics can provide the force required of many industrial applications. However, advancements in electric actuator technology over the last 30 years have made them a viable alternative.

Also referred to as electromechanical actuators, these devices are able to provide improved precision, flexibility and reliability with a bore size equivalent to that of hydraulic cylinders. Today's electric actuators are also capable of exerting up to 100,000 lbs. of force, enabling them to compete with many hydraulic technologies.

This is not to say that hydraulics will be completely replaced by electric actuators in industrial applications. The high force, compact size and rugged design offered by hydraulic cylinders as well as the fact they are simple to deploy continue to make them a good choice for many types of industrial machines.

But there are also many benefits offered by electric actuators which have led to their increased use in recent years.

Three Reasons to Choose Electric Over Hydraulic Actuators

According to Tolomatic — a developer of electric, pneumatic and other motion components — there are a variety of reasons its customers are choosing to use electric actuators over hydraulic cylinders, but three main factors are driving the shift to electric:

- reduced footprint and system complexity,
- fewer maintenance requirements, and
- motion control flexibility.

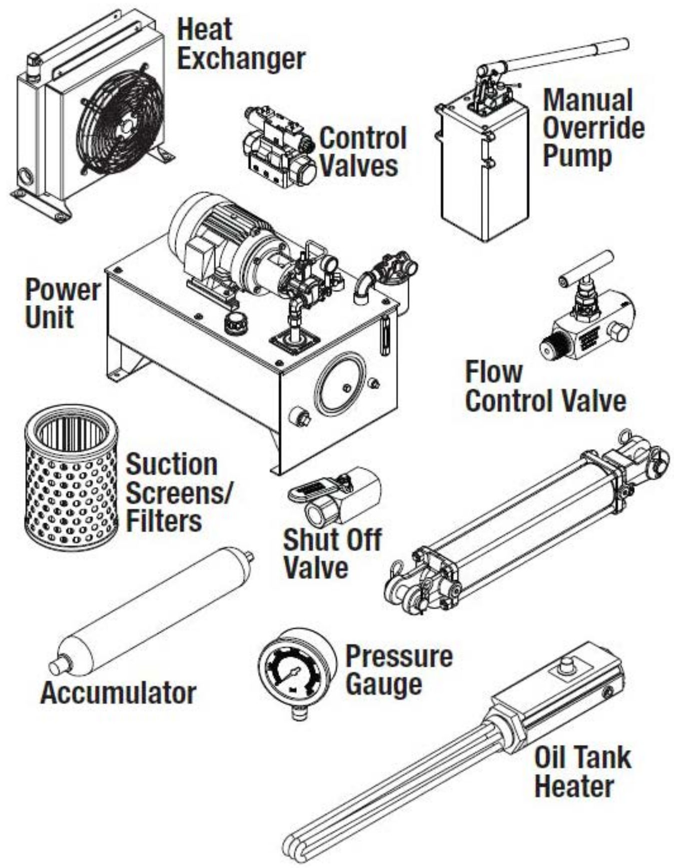
Design Simplicity

The design of electric actuators is not as complex as that of hydraulics, which is one of the reasons customers choose them over the latter. As Tolomatic explained to *Power &*

Motion, there are very few components in an electric actuator compared to a hydraulic system. Hydraulics require valves, regulators, hoses, hydraulic power units (HPU) and more. And there is the potential for any of these components to leak or fail over the life of a machine, the company said.

If the hydraulic system leaks, the hydraulic oil can be time consuming to clean up and could cause potential environmental concerns. There is also the potential for safety issues if oil contaminates manufactured products.

All the components required by a hydraulic system necessitate a larger footprint in a manufacturing facility, as well, which can be difficult to accommodate if space is at a premium.



One of the drawbacks associated with hydraulics is the amount of components included in these systems which can add complexity and potential leak points. Tolomatic

Electric actuators, on the other hand, do not use oil and therefore leakage issues are not a concern. In addition, they have a smaller overall footprint as the system consists of the actuator, a motor (often a servo or other device), cables, and a drive or amplifier which is typically housed in a control cabinet. There may also be an optional gearbox.

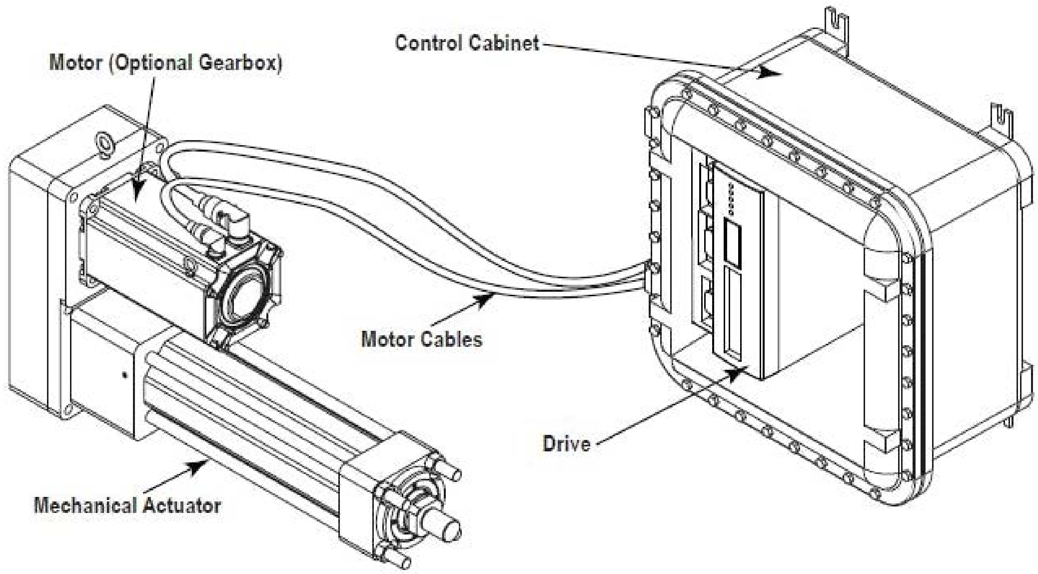
Per Tolomatic, an electric actuator does require more length than a hydraulic cylinder because of its integrated power screw and bearing system but it uses a servo drive which is a fraction of the size of the HPU utilized by hydraulic systems, helping to provide a smaller overall footprint.

The company said the growing use of planetary roller screws in electric actuators have helped them achieve higher life ratings and greater force capabilities in a much smaller package (versus ball screws). This enables electric actuators to fit into some applications previously dominated by hydraulics.

Reduced Maintenance

The lower maintenance requirements of electric actuators are helping drive their use over hydraulics as well. According to Tolomatic, electric actuation has very little to no maintenance over the life of a machine.

Use of planetary roller screws in electric actuators has enabled the longer life and low



Electric actuators offer many benefits over hydraulic cylinders such as improved position control and repeatability. Tolomatic

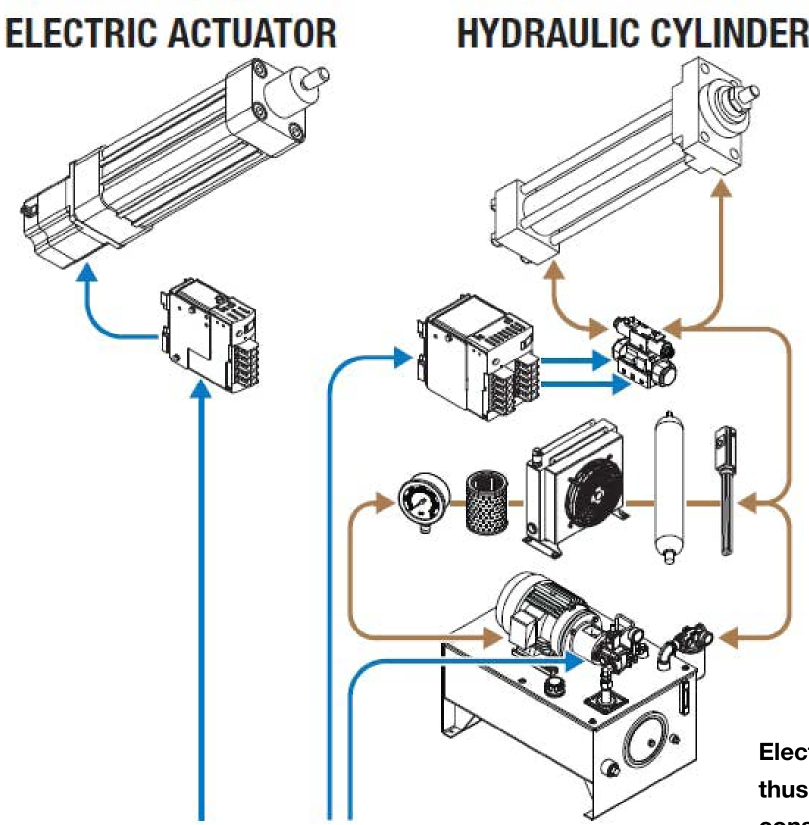
maintenance desired by many machine users, the company noted. In addition, the power elements (power screw and thrust bearings) of the actuator are usually greased for life. But in-field greasing methods can be used if needed.

The other component on an electric actuator which could wear is the rod seal. If failure occurs, though, the actuator can still operate as desired because it does not hold pressure like a hydraulic component would. And the seal can be replaced if damaged.

A hydraulic system typically requires routine maintenance to change the oil and filters in order to ensure continued performance. It may also be necessary to replace fittings, valves or other components over time.

Tolomatic noted there is also a growing lack of skilled maintenance people knowledgeable in hydraulics which is helping fuel the speed of adoption for electric actuation.

READ MORE: Increased Demand for Uptime and Reliability Driving Move to Electric Actuators



Electric actuator systems have fewer components and thus a smaller overall footprint which can benefit space-constrained applications. Tolomatic

Improved Precision and Position Feedback

One of the top reasons electric linear actuators are chosen over hydraulic cylinders is the motion control capabilities they provide. The pairing of electric actuators with a servo drive and motor system allows users to know with certainty the actuator's position at all times as well as its speed, accelerations, forces, and more. Whereas a hydraulic system would require a number of expensive instruments to be added to the system to get similar information.

These capabilities enable more accuracy and repeatability to be achieved with electric actuators which benefits a range of industrial applications, especially as they become more automated.

Additional motion control benefits offered by electric actuators outlined by Tolomatic include:

- thrust capabilities on par with hydraulics are possible,
- consistent monitoring of torque allows appropriate force control without maintenance or system adjustment,
- closed-loop control enables multiple positions to be achieved without the use of external sensors.

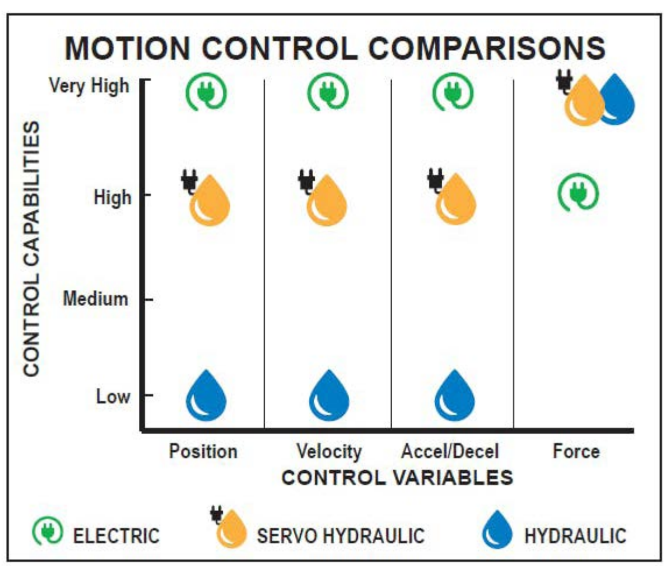
Hydraulic vs. Electric Actuators: Key Deciding Factors

Although there are many benefits to using electric actuators, there remain applications for which hydraulics are still a good fit.

Tolomatic said there is no doubt that hydraulic cylinders have the capability to provide great power density which means there are some machine installations where it is not currently feasible to utilize electric actuators. There are electric actuators available in the market capable of up to 50 tons of force, the company said, but forces above this point are less common for electric actuators due to the size of the screw/actuator and the availability and size of the servo motors. However, advances in technology may allow electromechanical actuation of higher force applications in the future.

Understanding the working force required of an application is a key determining factor when choosing between electric and hydraulic actuators.

The company said it always works with customers to determine the true working force of a hydraulic cylinder. The actual working force needs to be calculated by looking at the pressure drop of the hydraulic fluid in combination with the diameter of the actuator cylinder. The



Comparing the control capabilities of electric actuators and hydraulic cylinders can help determine the best option for a machine application. Tolomatic costs of electric actuators and motors can vary more significantly than hydraulic cylinders and is often the key in getting a cost-effective electric actuator solution, said Tolomatic.

An advantage offered by electric actuators is the fact that force can be generated instantaneously unlike a hydraulic cylinder which has to wait for pressure to build up to create the required force. Adjustments to the actuator's performance can also be done automatically because its servo controller regulates the electrical current used to power the device which is available as needed.

Conversely, the HPU used with a hydraulic system must always keep pressure in the system which can be difficult to do and thus can have an impact on response time and the ability to adapt to any necessary performance changes.

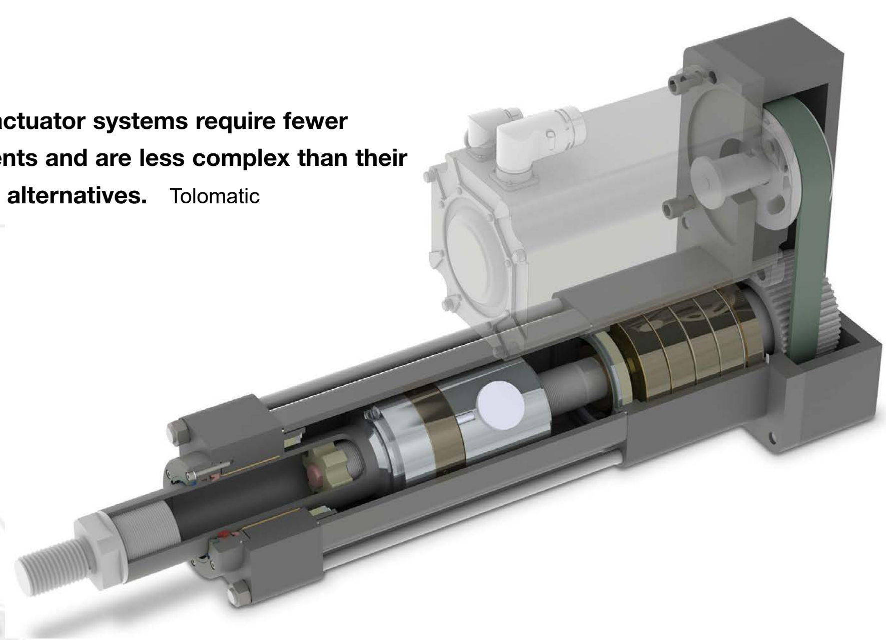
The environment in which a motion system will be used is also important to take into account. Temperature fluctuations, for instance, can impact the performance of hydraulic oil and thus the overall system. Additional components and maintenance may be required to keep the oil heated or cooled to an appropriate temperature so it can flow through the system as desired, ensuring consistent performance.

Electric actuators, on the other hand, are not typically affected by temperature. The actuators can overheat but that is often due to extreme changes in duty cycle, or it not being sized appropriately for the application. And if used in a cold environment there are greases which can be used to ensure performance.

Noise is another environmental factor to take into consideration. Hydraulic systems tend to be noisy, which could be a concern for machine operators. Minimizing the amount of noise emitted from a machine through use of a quieter electric actuator can increase safety and comfort for operators.

This helps create a more desirable working experience, an increasingly important aspect as manufacturing — like many industries — is struggling to find skilled workers. Offering a safe and comfortable work environment not only aids employee retention but also the ability to attract new potential employees.

READ MORE: Understanding When to Use Hydraulics



Electric actuator systems require fewer components and are less complex than their hydraulic alternatives. Tolomatic

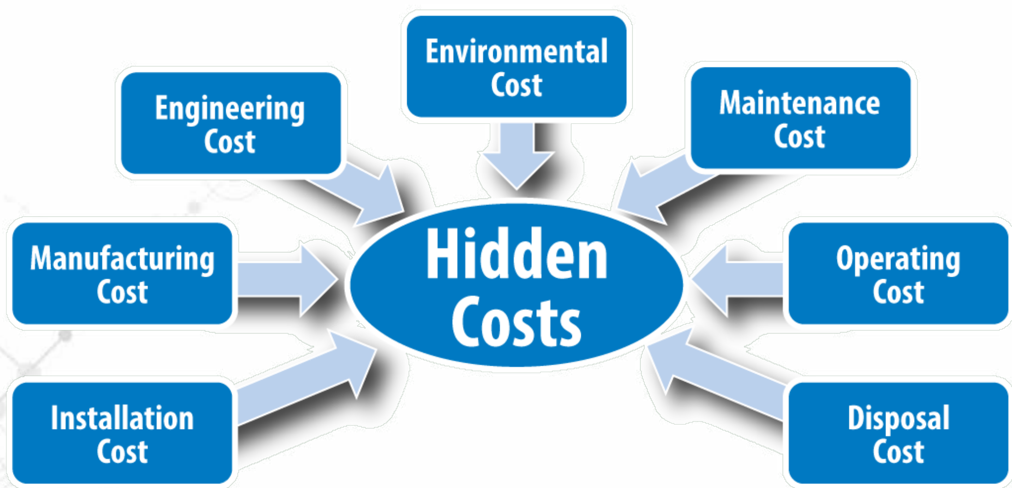
Evaluating Total Cost of Ownership is Important

One of the biggest challenges associated with the switch from hydraulics to electric actuators is customers having knowledge and confidence in both technologies, said Tolomatic.

The company said there are many people who have been working with hydraulics for a long time but unaware or less comfortable with electric alternatives. Conversely, there are many people who are earlier in their careers and have grown up with electric technology which has provided them with a desire for more control and data collection, leading to a preference for electric actuators. They may also be less familiar with hydraulics which further influences their actuation technology choice.

More industry education on the pros and cons of each as well as working directly with a motion control technology supplier like Tolomatic can help provide a better understanding of both systems so a more informed decision can be made.

In addition, evaluating the total cost of ownership (TCO) associated with electric linear actuators versus hydraulic cylinders can help determine the best option for a given machine application. When doing so, Tolomatic points to the iceberg principle – the initial cost of a hydraulic cylinder-based motion system is less than that of an electric actuator one but there are more costs under the surface which can impact TCO.



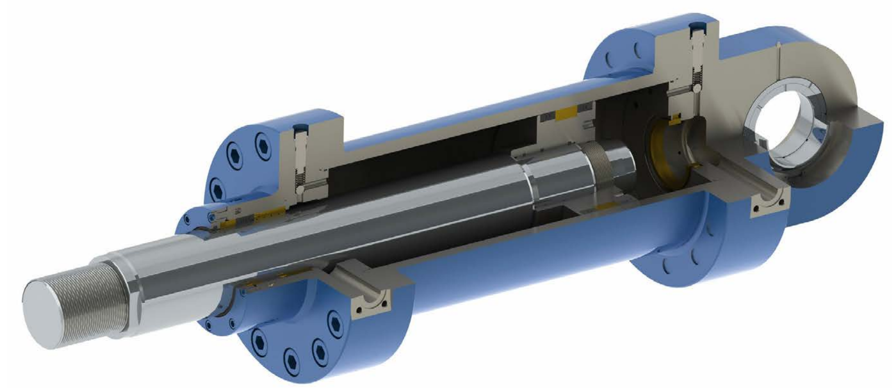
The initial cost of hydraulic cylinders may be lower than electric actuators, but there are also several hidden costs which should be taken into account when determining the best solution for an application. Tolomatic

As noted previously, hydraulic systems require more maintenance which leads to operational costs over the life of a machine. Energy used to power the system, disposal fees for the hydraulic oil as well as needing replacement filters on hand should all be taken into account when assessing the TCO of a hydraulic system.

While electric actuator systems cost more up front to install, they tend to have a lower TCO compared to hydraulics. This is due in part to the minimal maintenance required by these systems as well as their ability to perform more accurately and efficiently.

Per Tolomatic, electric actuator systems usually operate in the 75-80% efficiency range while hydraulic actuator systems are in the 40-55% efficiency range. The more efficient a system is, the less energy it will use and thus lower utility costs.

Related to this, electric actuators demand current only when needed so if at rest there



Hydraulic cylinders provide the high force required of many industrial applications as well as a rugged design which will continue to make them the technology of choice in many applications.
Tolomatic

is little to no energy being used. Hydraulic systems, however, require the HPU to be pressurized at all times to ensure the system is ready to work when needed which is not as efficient a use of power.

Efforts are being made by the fluid power industry to improve the efficiency of hydraulic systems as various industry sectors look to improve their energy use and overall environmental impact. These efforts, paired with the force capabilities and other aspects, will help to keep hydraulics in use for years to come where appropriate.

Tolomatic concluded that the list of applications which are moving from hydraulic to electric actuation continues to grow every year. The company said it is continually working with customers to address their unique application situations to ensure an electric actuator system meets all performance requirements. While a shift to electric is taking place in the industrial sector, Tolomatic also noted there will continue to be applications in which hydraulics and pneumatics are the right technical solution.

Get to Know Industrial Hydraulic Actuators

Many industrial machines — such as metal presses, conveyor belts, cranes and others — need to move objects in a straight line which is achieved through use of a linear actuator. For decades, this linear actuator has come in the form of a hydraulic cylinder as it can provide the high force required of many applications.

These cylinders can have anywhere from a 1-8 in. bore and operate within a range of 2,000-3,000 psi (138-207 bar). They are also able to exert 1,700 to over 110,000 lbf (55 tons) of force.

Besides their high force capabilities, hydraulic cylinders are known for their durability and compact size. As hydraulic technology has existed for centuries, it is also a well understood technology.

Learn more about the differences between hydraulic, pneumatic and electric actuators in the article "Sorting Out Linear Actuators."

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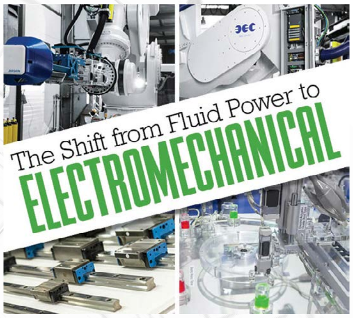


Ewellix, a Schaeffler Company

CHAPTER 2:

Electric Actuators Shine in Lower Horsepower Applications

SARA JENSEN, Executive Editor, *Power & Motion*

Machines operating at a lower horsepower or with fewer actuation needs are those in which it currently makes the most sense to replace hydraulics with electric actuators.

Hydraulic systems are, and will remain, an important part of many mobile machinery applications. But there are some instances in which it can make sense to convert to electric actuator options, such as when needing an oil-free solution or improving the efficiency of battery-electric machines.

According to Kirk Martin, Sector Sales Director Mobile Machinery at Ewellix, a Schaeffler Company, lower horsepower applications with limited actuation needs are those for which electric actuators can provide a viable alternative to hydraulics.

In this interview with *Power & Motion* Martin discusses why the transition from hydraulic to electric is taking place, the benefits most suited to using electric actuators and the benefits, as well as challenges, with moving to fully electric actuation.

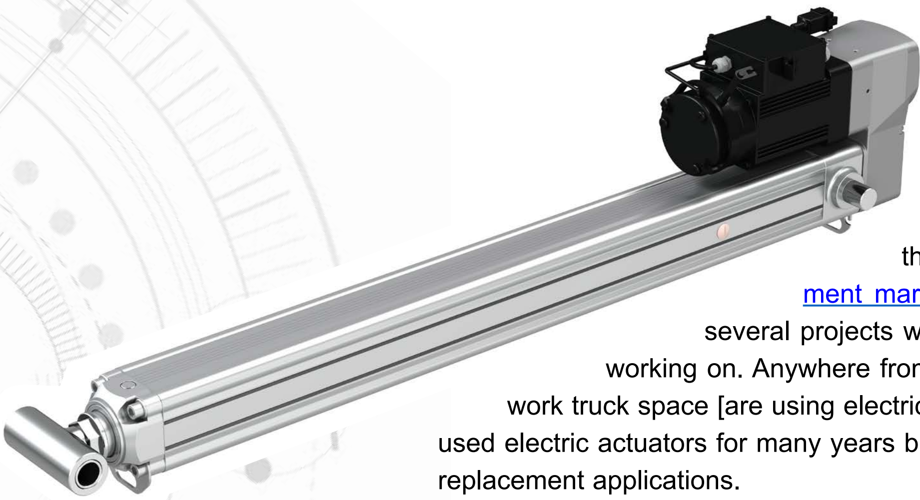
Editor's Note: Questions and responses have been edited for clarity.

Power & Motion (P&M): What is driving the shift away from hydraulic technologies to electric actuators in mobile machinery applications?

Kirk Martin (KM): It is kind of connected with the electrification movement going on within the off-road world [and] the trend toward zero emissions. They [OEMs] always look at that as the first step, to replace the internal combustion engine with a battery system. And then the second step a lot of times they want to make it more efficient, or they want to have oil-free features, and the electric actuation system can do both of those. So those are two of the main driving forces.

P&M: Where are you seeing electric actuators replacing hydraulics in mobile equipment — are there specific types of systems or machines where this is occurring?

KM: There's a couple of companies that have fully electric machines out there, one



Mobile applications requiring just one or two actuators are those which can most benefit from replacing hydraulics with electric options.

Ewellix, a Schaeffler Company

of them is in the scissor lift market and then there's another in the small construction equipment market. Those are the only two so far, but there's several projects we're working on [and] I'm sure other people are working on. Anywhere from the AWP (aerial work platform) markets to the work truck space [are using electric actuators], and also agricultural equipment has used electric actuators for many years but now they're starting to look at a few hydraulic replacement applications.

In general, most projects are under 50 kW (75 hp), [that is] the size machine that [many are] looking at. But we've got projects in all those different industries around the globe.

P&M: Is there a particular reason those lower horsepower applications are being looked at, is it just that's where the technology is currently?

KM: For us and our company that's where we have the technology. We do get requests for larger applications, but it fits cost wise with what's out there [and] what the batteries can do. It makes sense is in the smaller machines [many of which] are going into municipalities where they want to have zero emissions. There are bigger equipment applications that [are aiming for] zero emissions but for us electric actuators are fitting into [applications] under 50 kW. It's a good guideline for what our projects are following.

P&M: What are the best use cases for electric actuators in mobile machines?

KM: The applications we're seeing where it makes the most sense is where there is only one or two actuators. Some machines that have multiple cylinders like an excavator, skid steer or tractor loader, it gets economically more challenging the more cylinders there are. We've seen the most sense [for electric actuators] so far in scissor lifts and some work truck applications as there is only one or two cylinders on a machine.

P&M: What are some of the key factors which need to be considered when moving from a fluid power-based system to an electric actuator one?

KM: One of the main ones is what voltage you want to have on your machine and what voltage you want to have the actuator at, that drives the motor, the controller and everything else. Another big one that is needed for electric actuators versus hydraulics – you don't necessarily need to look at it quite as heavily — is the duty cycle which has a large impact on the size of the actuator.

The other thing that is needed is if there are two actuators in parallel; you need to know that and take it into account because electric actuators have to synchronize so it takes some control technologies to do that. Space claim is a big factor [as well], it is not a drop-in replacement. And the last [factor], it is probably the most important, is what is the average load, not the maximum load, so we can really optimize the electric actuator.

READ MORE: The Basics and Benefits of Electromechanical Actuators

Electric actuators require their motor and gearbox to be placed at the point of motion, necessitating some additional design work to install them.
Ewellix, a Schaeffler Company

P&M: And would a company like Ewellix work together with an OEM to help with that transition from the hydraulic systems they normally use to electric actuators?

KM: Yes. In our case we've got a pretty large team of engineers engaged with their customers' engineers because there's a lot of CAD models that have to go back and forth and having to change the framing of the machine. Like I said, it's not a drop-in replacement, it's not an easy process. It does definitely take some development time.

P&M: What are some of the biggest challenges related to replacement of hydraulic technologies with electric actuators, and how can these be overcome?

KM: As I mentioned previously, the space claim is the biggest challenge. For a hydraulic cylinder the motor is on the engine or near the battery pack. In our case, the motor and gearbox have to be at the point of motion, so there's a big space claim. Most cases you have to redesign your frame.

The other [challenge] is cost. It's still a cost adder, there's no guideline on how much. But those are some of the biggest challenges.

I think as we go forward, if people get used to designing them in on new machines rather than trying to retrofit existing machines it's not [going to be as] big a challenge. The cost will continue to get better and go down as more people [use electric actuators and] the volumes get larger.

P&M: What benefits, besides trying to achieve zero emissions or efficiency, are there to moving to an electric actuator system?

KM: Those are the main two that we see customers consider because if you have a battery [powered] machine, you want efficiency. We see a lot of environmental places along the coast or on oceans, they don't want to have oil in their machines, at ports and facilities like that, so we see that as really being a driver.

There are some other features that people like once they get into it, [electric actuators are] very controllable, a lot easier control typically than hydraulic systems today. It's also a very simple system, there's no filter, you don't have valves, [and] you don't have hoses. Every customer has got different reasons why, but I think efficiency and the lack of hydraulic oil are still the two major driving factors.

READ MORE about Ewellix's electric actuator technology in the article "Electric Actuators with Integrated Control Technology Provide Seamless Installation."

The Ewellix CAHB electric actuator is equipped with the company's SmartX platform, a CANbus control package with absolute position control. Ewellix, a Schaeffler Company

P&M: How do you see use of electric actuators in mobile machines progressing in the coming years? What will aid, or hinder, continued use of this technology in these machines?

KM: Cost and development time — a lot of customers just want to do it quick and drop it in, with a battery system it's not easy but it's not quite as big a challenge as a combustion engine [which] takes a lot of space. There's a lot of development time to get [electric actuators installed]. And upfront costs on actuators is quite a bit more [but] customers find long term it's worthwhile because you don't have any maintenance really required, so the long-term equation looks good. Those are two of the major hinderances.

I think what will help it are the environmental policies that are going on around the world. People are realizing they need to look at the environment in their designs. And I mentioned before the increased volumes — as the motors get cheaper the actuators will get more cost effective. I think those [factors] will help drive it.

Certain applications will go [to electric actuators]. Some markets, such as large excavators I don't know if they'll ever go fully electric. But I think the smaller machines with one or two actuators, or a machine where there's an actuator way out on a boom where it is cost prohibitive to run hydraulic hoses, sometimes electric is easier in that situation. So, once again, small actuators [on] small machines with one or two actuators is where I think it'll really go.

Watch "Electric Actuators Present Emissions and Efficiency Benefits in Mobile Equipment" for the video version of this interview with Kirk Martin.

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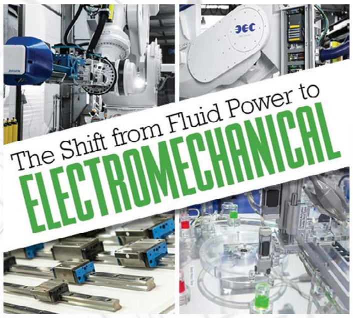

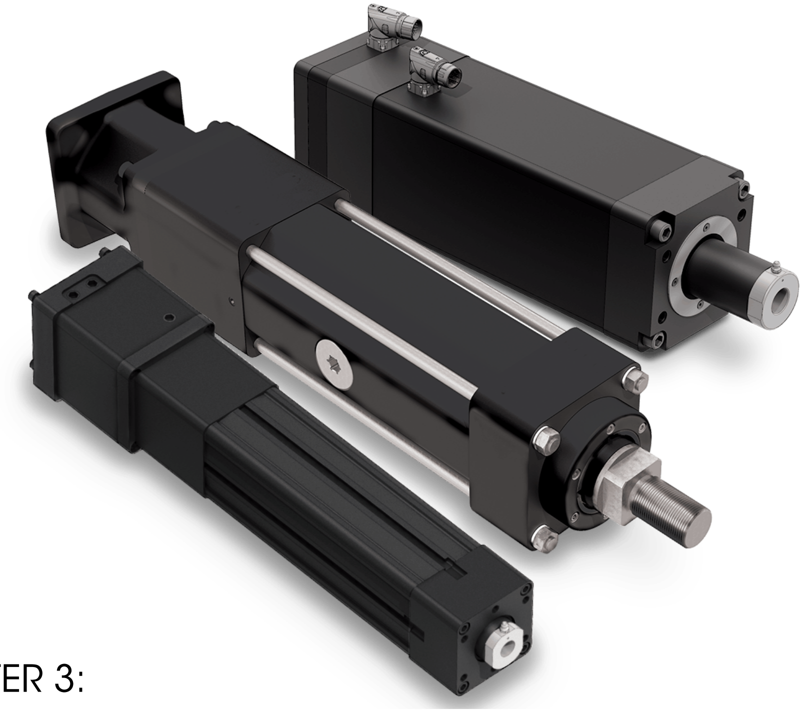

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CHAPTER 3:

Converting from Hydraulic to Electric Actuators: Key Steps to Follow

SARA JENSEN, Executive Editor, *Power & Motion*

Learn the key steps to successfully convert from hydraulic to electric actuators, including how to accurately determine loads and forces to ensure an optimally sized and priced system.

Use of electromechanical systems is increasing in several industrial machinery applications because of the precision and reliability provided. In many cases, they are replacing the hydraulics traditionally used in these machines.

While hydraulics will continue to be the technology of choice in many applications, for those where an electromechanical (i.e., electric actuator) option can be used it is important to understand how to convert from one technology to the other to ensure optimal machine performance.

Ryan Klemetson, Business Development Manager at Tolomatic, explained during a webinar hosted by the company on converting from hydraulic to electric actuators that key steps to a successful conversion include determining the loads and forces of the application, and defining its required motion profile and cycle rate.

Following these steps will ensure the performance of an industrial machine is maintained and the benefits of converting from hydraulic to electric are achieved.

Factors to Consider Before Converting to Electric

When looking to replace a hydraulic system with an electromechanical one, it is important to take some factors into consideration to ensure the conversion is feasible.

One of the first factors to assess is the space envelope available for the system. As Klemetson explained in the webinar, hydraulics are very power dense and so machines have always been designed to optimize footprint. Because of this there may not be room for an electric actuator and its accessory components.

Electric actuators tend to require more space than a hydraulic cylinder because they are longer and wider. There is also mounting design work which needs to be taken into account.

Hydraulics Remain a Vital Method of Motion Control

Although electromechanical options are being used in place of hydraulics in many applications, there will always be a need for hydraulic systems. "Hydraulics can still do work that conventional electromechanical technology simply can't," said Ryan Klemetson, Business Development Manager at Tolomatic, during the company's webinar on converting from hydraulic to electric actuators.

He said the shift to electromechanical is no different from the one which started about 15-20 years ago when people began re-evaluating their pneumatic systems to see if different technologies could be used to improve processes and efficiency.

"We're starting to see more applications…following that same process of 'How do I evaluate where the best use of the tools is in different applications or equipment?'" said Klemetson.

Because hydraulics can provide higher power density than other motion control technologies, they will remain an important part of many applications for years to come, particularly those requiring a high level of force or movement of heavy objects. Understanding the pros and cons of hydraulic- and electric-based systems can ensure the right option is selected for a given application.

Read "Understanding When to Use Hydraulics" to learn more about how to choose between hydraulics and other motion control technologies.

Force levels and stroke length should also be considered, again in relation to how much space is available. While today's electric actuators can achieve high forces they are not as power dense as hydraulics which means they need more space to provide forces similar to that of the hydraulic cylinder they are replacing.

"It is all about finding the right tool for the job," said Klemetson. Therefore, having a good understanding of the machine design and its intended use will aid in determining if an electromechanical system will fit the application.

READ MORE: Increased Demand for Uptime and Reliability Driving Move to Electric Actuators

Accurate Force Measurements Ensure Proper Electric Actuator Sizing

Appropriately sizing the electric actuator that will be used in place of a hydraulic cylinder is one of the first steps in shifting from a hydraulic to electromechanical system. To do so, it is necessary to determine the force and load of the system.

Klemetson said Tolomatic always recommends measuring the force of a system as opposed to basing it on system pressure which is often done using the following formula:

$$\text{Force} = \text{Area of the Cylinder} \times \text{Rated System Pressure}$$

This can result in an electric actuator solution which is oversized and overpriced. Instead, a more accurate measurement of force can be achieved by measuring hydraulic pressures in a cylinder while a machine is in operation.

"Where to measure is kind of a good, better, best," said Klemetson. "The best place to always measure would be right at the point of work." This is not always feasible though, but there are ways to still get accurate force measurements.

Using the good, better, best analogy, there are three areas within a hydraulic system where pressure measurements can be taken (see Figure 1 below):

- Good – Measure pressure at the valve, which is the commonly used option when converting to electric actuators. It is the furthest distance from the work point, though, increasing the potential for errors in actual versus measured pressure.
- Better – Measure pressure between the hydraulic system's valve and cylinder. However, pressure-compensated flow controls and needle valves or other inline accessories could influence pressure.
- Best – Measure pressure at the hydraulic cylinder. This is the most accurate location

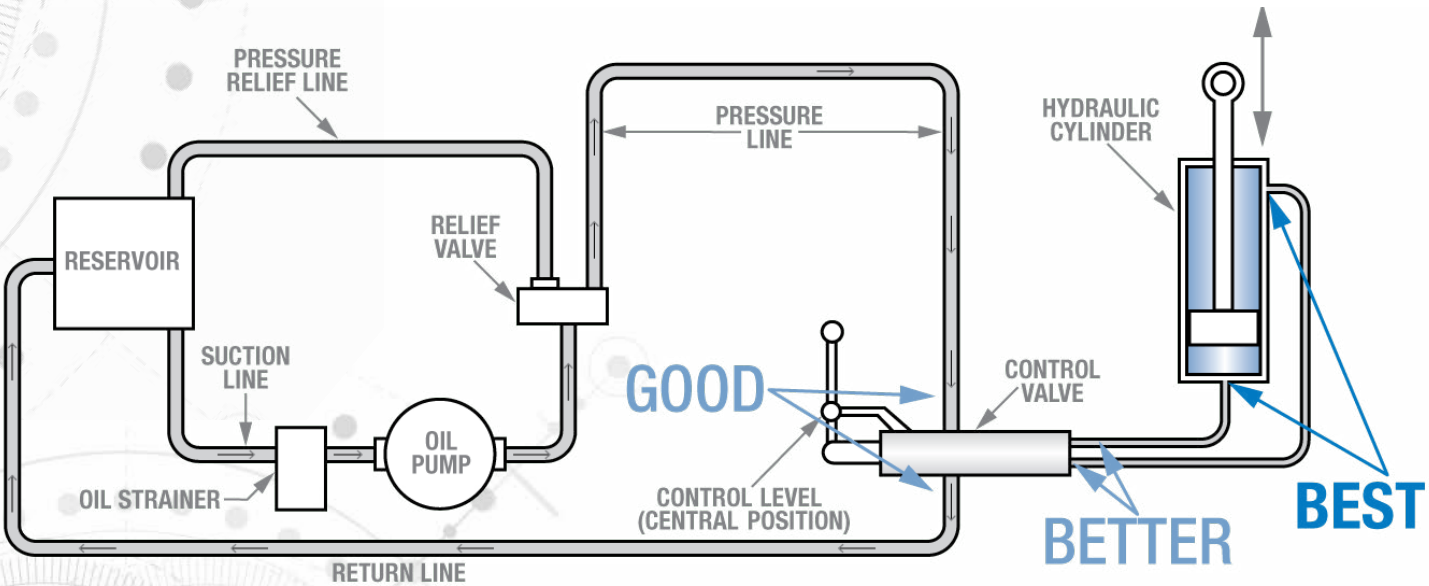


Figure 1: To determine application forces for replacement electric actuators, the best option is at the point of work. But given this is not always possible, there are other points at which measurements can be taken as illustrated in this figure. Tolomatic

for reading pressure at the point closest to where work is happening but may also be the least accessible location.

"The more accurate you are in measuring, the more optimized you're going to be as far as the cost of your system," said Klemetson.

Because every hydraulic system is different, Tolomatic recommends measuring both working pressure of the system and the return pressure as there is the possibility of high return pressure between the system's cylinder and valve. This can reduce the total force of the system.

Therefore, it is recommended to place measuring gauges on both the extend and retract ports of the hydraulic cylinder (see Figure 2 below) and calculate effective surface pressure:

$$\text{Force} = (\text{Area1}(\pi r^2) \times P1) - (\text{Area2}(\pi r^2) \times P2)$$

He gave the example of a small hydraulic system featuring a 1.5 in. bore cylinder with

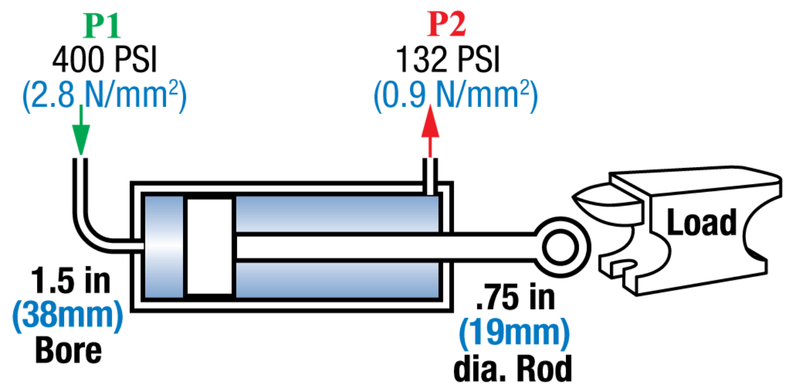


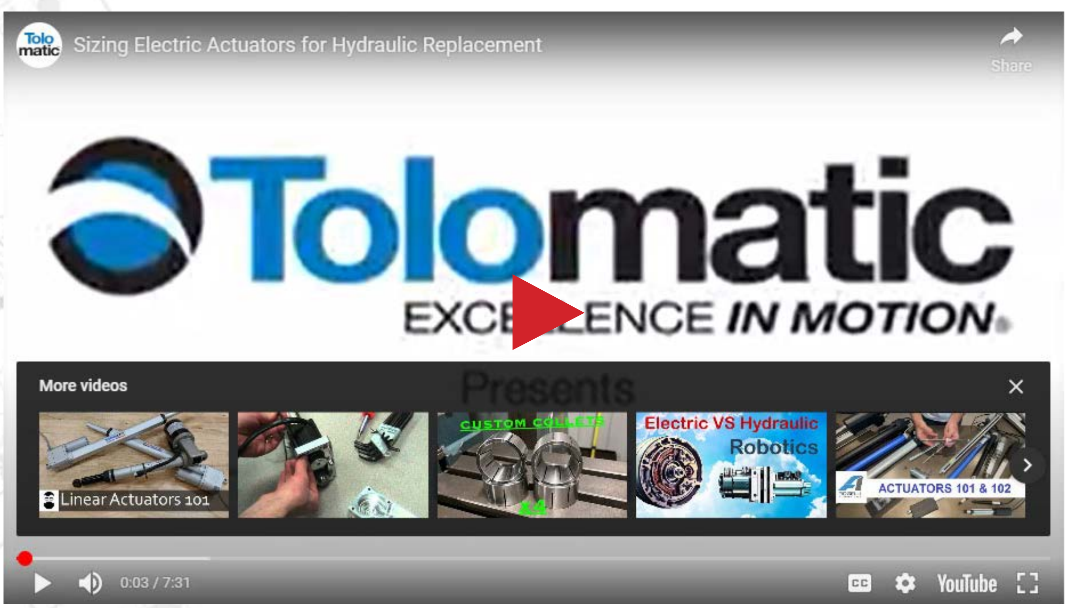
Figure 2: The most accurate method for sizing an electric actuator is to calculate the force on each side of the hydraulic cylinder it will replace to determine the force and load requirements of the system. Tolomatic

0.75 in. rod and pressure relief valve set at 1,500 psi (103 bar). If doing a simple Area x Pressure calculation, the resulting force would be 2,60 lbf.

But if 250 psi (17 bar) of backpressure is factored in, that leads to a 40% reduction in required force (1,788 lbf) and thus a smaller sized system than might have originally been designed. Taking backpressure into account "could literally in some instances save you thousands of dollars," said Klemetson. "So, we always recommend this as the most accurate" method of determining force requirements.

[READ MORE: The Basics and Benefits of Electromechanical Actuators]

Watch Tolomatic's video "Sizing Electric Actuators for Hydraulic Replacement" to learn more about properly selecting the right actuator for use in place of a hydraulic cylinder.



Know Your Application for Component Selection

Understanding the desired motion profile of an application is another critical step when replacing a hydraulic cylinder with an electric actuator. It can be captured simply with a stopwatch or a camera to help determine the requirements of the application.

"It's important to understand what is necessary — either I need to move at a given rate or I need to move a distance in a given time," said Klemetson. "The reason this is important is typically when you get into larger force applications, servo motors don't spin as fast when they are very large. You may only have 2,000 [or] 2,500 rpm versus 6,000 rpm."

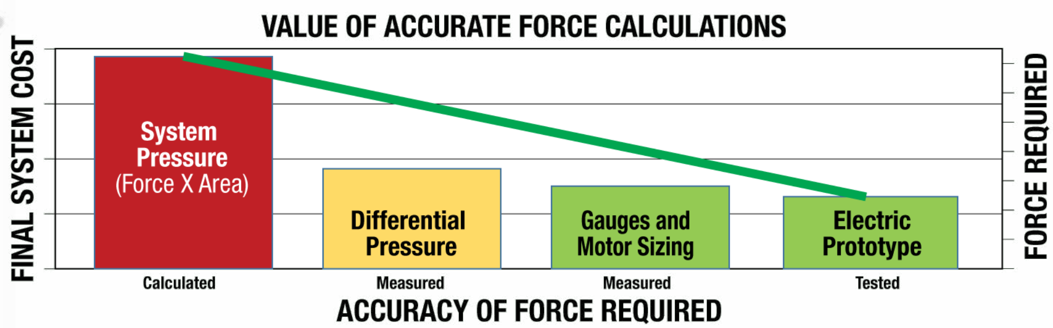
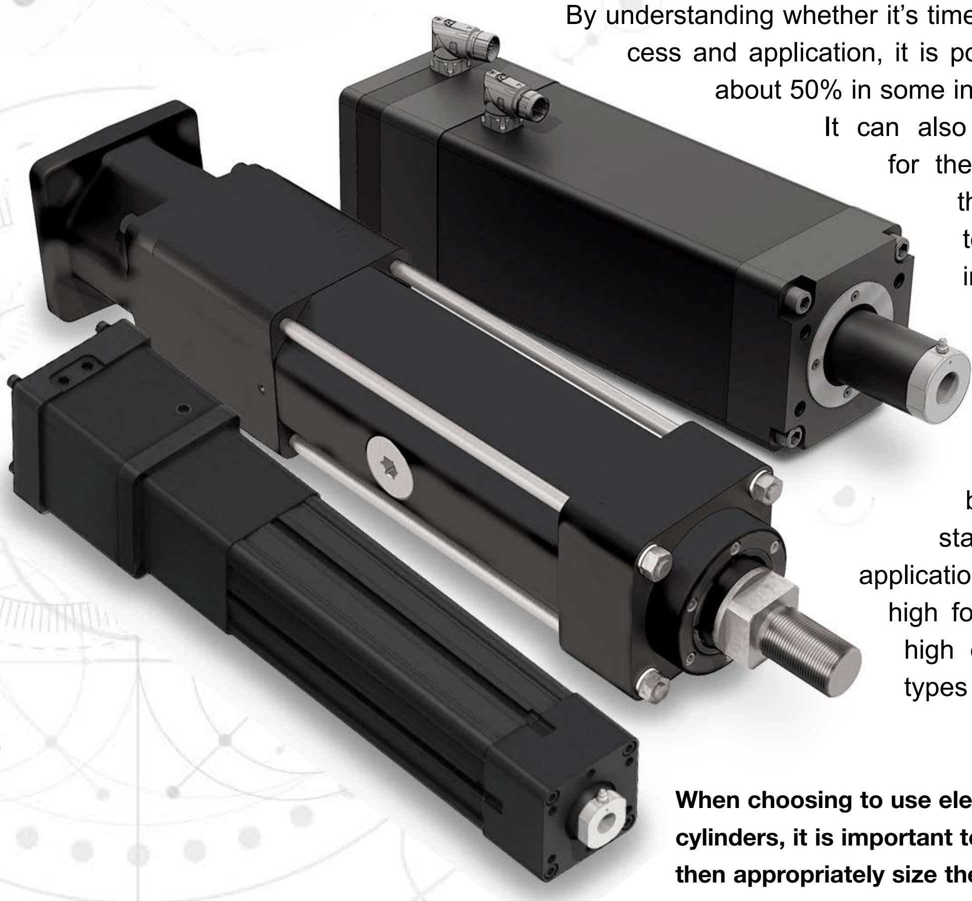


Figure 3: Accurately determining force requirements ensures the replacement electromechanical system is not only optimized for size but also cost. Tolomatic

By understanding whether it's time or speed that is important to your process and application, it is possible to reduce your motor speed by about 50% in some instances.

It can also help to inform component selection for the electromechanical system. Choosing the appropriate electric actuator screw technology (Acme, roller or ball), for instance, will correlate not only to system performance but also potential heat generation and maintenance requirements.

Klemetson noted during the webinar that roller screws tend to perform better than ball screws from a longevity standpoint in pressing and high-shock applications. Roller screws are known for their high force capabilities, low maintenance and high efficiency, all of which benefits these types of applications.



When choosing to use electric actuators in place of hydraulic cylinders, it is important to first determine space available and then appropriately size the actuator for the applications. Tolomatic

When you have a good understanding of your application and maintenance needs, it plays "into picking optimized components from a size and ultimately a cost perspective," he said.

Take Full System Needs into Account

Klemetson said it is also important to remember you are engineering a system and therefore all necessary components need to be factored into the design process. Besides the electric actuator there is the motor and the drive which need to be taken into consideration as well as the power level that will be used.

"All of these play into the electrical side of it," he said. Here again, understanding your application needs will aid with selecting the right types and sizes of electrical components that will be required.

One of the aspects which he said is often forgotten about is the cabling. "Hoses [and] fittings don't care too much about laminar flow or turbulent flow but with electricity it's pretty important," said Klemetson. "Anybody that is going to be designing a system, make sure that proper cabling is selected, [and] proper wiring and installation cable dressing is followed."

He said Tolomatic will often receive calls from customers that their actuator is not moving, and it turns out to be an issue with grounding, shielding or cabling. "From that standpoint, it can be a very challenging thing…and a chronic problem if it is not addressed at the beginning."

Therefore, it is important to remember all components that will be used in an electromechanical system and that everything will work together as desired.

By following these steps, it is possible to achieve a successful conversion from hydraulic to electric actuation in your industrial machinery.

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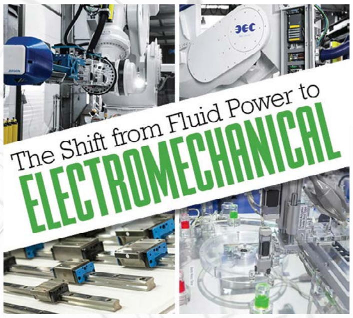


Garn Phakathunya | Dreamstime.com

CHAPTER 4:

Choosing the Right Linear Actuator to Boost Automation System Performance

NIKLAUS ROETHLISBERGER, Product Manager for Actuators, *Emerson, Afag Automation AG*

LINDA SCHWARTZEN, Product Marketing Manager for Actuators, *Emerson*

Understanding available electric linear actuator types and their performance characteristics ensures the right option is selected for a given automation system.

Electric linear actuators are valuable and versatile systems that provide fast, efficient and accurate movement of products and materials in today's high-speed factory automation systems.

Manufacturers offer multiple electric linear actuator models for both single-axis and multi-axis applications. These actuators use a range of designs and motion components to serve different load, accuracy and speed characteristics.

Choosing the right electric linear actuator calls for a deeper understanding of the options available in the industry. With that understanding, original equipment manufacturers (OEMs) and end users can match a selected actuator's capabilities to the long-term efficiency, productivity and control each machine or production line requires.

Growth of Electric Linear Actuators in Automation

There is steady growth in the use of electric linear actuators in highly automated industries. Electric linear actuators are widely used in automated production platforms with high-speed throughput requirements and repetitive linear motion cycles.

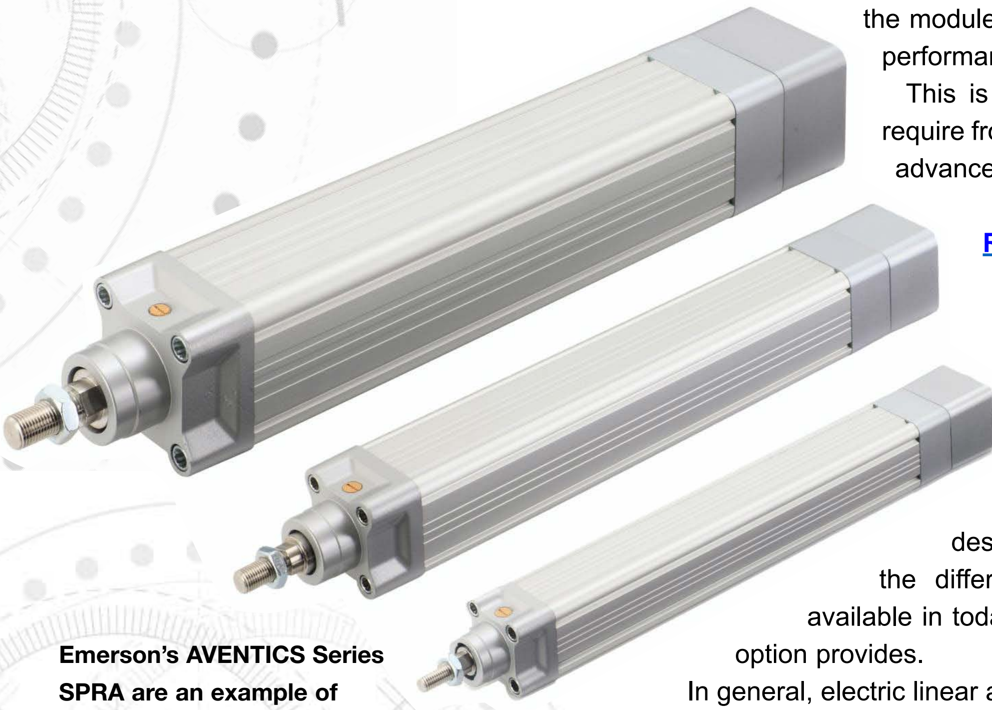
Some heavier industries, such as automotive and tire manufacturers, are in the early stages of adding electric actuators to their production platforms while continuing the use of pneumatic actuators in certain applications and machines.

Automation-intensive segments such as food processing and packaging use a hybrid mix of both pneumatic and electric actuators to drive linear tasks in their machines. In industries such as semiconductor, pharmaceutical and electronics production, electric linear actuators provide very stable and vibration-free linear motion combined with highly accurate and repeatable endpoints, a critical requirement for automated production in these segments.

One main advantage electric linear actuators offer is advanced motion control. Powered by electro-servo drives and motors and connected to production system PLCs, electric linear actuators can provide more agile and flexible control of critical motion factors such as speed, cycle time, endpoint accuracy and repeatability.

In addition, with the built-in power regeneration capabilities common in today's servo drives, linear actuators can offer automation system designers improved energy efficiency. Smart servo drives combined with sensors embedded in the modules supply crucial real-time data on actuator performance, efficiency and repeatability.

This is critical data manufacturers now routinely require from technology used in their systems to help advance digital transformation in their operations.



Emerson's AVENTICS Series SPRA are an example of electric rod-style linear actuators which can offer the enhanced load capacity, accuracy and reliability that manufacturers need to maximize productivity. Emerson

READ MORE: Optimizing Linear Motion Solutions Using Hybrid Automation Systems

Assessing Actuator System Design Options

To select the right electric linear actuator, it is helpful for automation system designers to examine and better understand the different kinds of linear actuator technology available in today's marketplace and the capabilities each option provides.

In general, electric linear actuators can be easily categorized according to their drive mechanics. There are three broad categories of electric linear actuators: belt-driven modules, screw drive or spindle drives and linear motor actuators.

Each has specific speed, load bearing, accuracy and other functional characteristics that guide actuator selection, based on specific manufacturing requirements.

Toothed Belt-Driven Actuators

A belt-driven actuator has an electric drive that powers a toothed rotator at one end of the module. This model converts rotary motion to linear motion by means of a toothed timing belt connected between two pulleys at either end of the drive.

Belt-driven modules work well when the linear sequence calls for medium repeatability, approximately 0.05 mm in motion, although higher repeatability can be supported with the use of integrated direct measuring system sensors.

Typically they can support moving medium-sized loads up to 300 kg. They also work well with larger strokes and sequences requiring a motion velocity greater than 5 m/s. Belt-driven linear modules are widely used in packaging applications to transfer products from one production line to another; they are also used in automated factories producing

Toothed belt-driven actuators work well with larger strokes and sequences requiring a motion velocity greater than 5 m/s. Surasak Petchang | Dreamstime.com

automotive parts like electric motors.

Leading suppliers offer these systems in a wide range of profile sizes (profile widths) and lengths, making them a modular option for multiple applications. Belt-driven electric actuators are also well-suited for building multi-axis systems such as pick-and-place and Cartesian motion systems.

Spindle or Screw Drive Actuators

In these systems, a spindle or screw in the center of the actuator converts the rotary motion to linear motion to move the load. They provide very high rigidity and low deflection, enabling greater endpoint accuracy with each duty cycle, for applications requiring approximately 0.02 mm repeatability.

Spindle or screw drive actuators utilize a spindle or screw in the center of the actuator to convert rotary motion to linear motion to move a load. Nordroden | Dreamstime.com

These actuators support low to medium dynamics for applications requiring velocities up to 1.5 m/s. Their strength and rigidity also make them highly suited for placement and pressing applications where high force is needed, such as securely inserting an electric component into a larger assembly, such as an electric vehicle battery and material joining. They are also a good choice for vertical applications.

Direct Drive Actuators

In these modules, the belt or spindle is replaced with an electric linear motor that moves the module’s carriage directly, rather than converting rotary to linear motion. They support very high endpoint accuracy, up to 0.01 mm, in part because the force is directly implemented at the moving part (carriage) with no elastic components in between (e.g., the rubber toothed belt).

This direct control also makes very complex start/stop, forward/backward motion sequences possible by programming the linear motor controller. It also supports the broadest range of strokes and velocities up to 10 m/s, as well as very slow and constant movement — which can be a requirement for moving very delicate electronics or other products that are susceptible to damage (e.g., laser applications or printing to achieve a constant result).

Direct drive actuators are often available in very compact sizes, making them a good option for production tools such as semiconductor fabrication systems that need to conserve valuable floor space without sacrificing performance.

[READ MORE: Sorting Out Linear Actuators]

Guidelines for Optimal Actuator Selection

Every automation machine and production line has unique operational and performance requirements, including the unique specifications for linear motion and transport. Since no two machines are identical, several best practices provide useful criteria automation system designers can use to guide actuator selection.

Automation OEMs and end users should first clearly define what task each actuator must perform in a machine or production line. That requires defining the motion profile for each actuator — and in some complex automated assembly systems, different process steps will call for different actuators with specific capabilities.

The Afag SGE-40-P-IOL smart electric gripper can grip up to eight different workpieces. The SGE-40-P-IOL provides four-stage adjustable gripper force through IO-Link for easy adjustments to sensitive workpieces. Afag

A linear actuator motion profile defines key parameters such as load — how much a component or product weighs — as well as the dynamics of the motion: how fast the module accelerates and moves the load with each duty cycle. The moving mass must also be calculated; this includes the material or component being moved, along with the total mass of the actuator, cabling, integrated measuring devices, end grippers and other elements that make up the total load to be moved.

The stroke must also be defined: what is the distance the load must be moved and with what force; this last parameter is especially important if an actuator needs to firmly place or insert a component into a larger assembly. When assessing the force, it is important to factor in the direction of movement: will the actuator be moving product horizontally, vertically or at a certain angle?

Along with these other factors, defining the duty cycle is critical for selecting the most reliable actuator based on the expected long-term performance. For example, there are now modules available with a guaranteed 40 million duty cycles; these data points can help with rapid, high-throughput motion sequences. Within the duty cycle, pause times must also be considered. There is a big difference between actuators that move constantly and actuators that only move during one shift. Additionally, pause time during an individual cycle is important to note. An example of this could be one actuator needing to wait for another axis or process time.

Once defined, the requirement profile gives automation designers the critical criteria for choosing the optimal electric linear actuator for each part of a new machine or assembly line. It is also important to recognize that in some motion applications pneumatic actuators may provide an equally efficient and cost-effective solution.

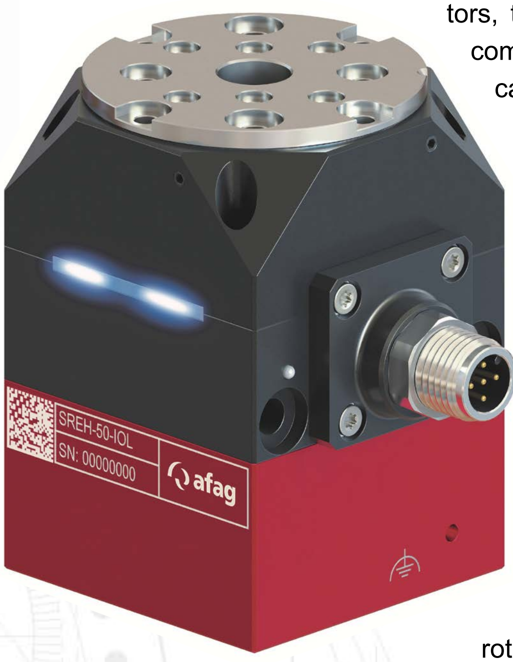
In addition, electropneumatic hybrid linear actuators can provide a versatile technology that combines the benefits of electric linear actuators and pneumatics. For example, when combining multiple belt-driven linear actuators into a Cartesian handling system for a pick-and-place application, pneumatics may be the most efficient way to actuate the gripper at the end of the Z-axis module in the system.

READ MORE: Pneumatics Help Automate Food Packaging

Working With the Right Actuator Portfolio

Once the requirement profile and linear actuator models are defined, choosing the right supplier is the next critical step.

It's important to assess the depth and breadth of each supplier's product lines. Does their portfolio include electric and pneumatic linear actuators, to provide flexible options? Can they provide complete linear solutions that include controllers, cabling, end effector grippers and adaptor plates when needed?



The Afag SREH-50 IOL smart rotary module is an innovative and compact electric linear actuator that features an integrated controller and planetary gearbox for more sophisticated linear motion profiles.
Afag

Today's leading suppliers configure the physical interfaces of their equipment so they can be easily combined together into multi-axis systems when needed. They also offer user-friendly online configuration and ordering tools to help system designers select and configure their modules based on the functional and performance requirements for each linear axis.

When assessing a portfolio, it's also important to review a company's ability to innovate. For example, one company recently launched a pioneering compact rotary actuator with the controller integrated into the module. This design saves control cabinet space and improves the motion control capabilities in the system.

Electric linear actuators provide an efficient and versatile tool to help create sophisticated production systems that deliver the performance manufacturers need. The range of electric linear actuator technologies now available gives automation system designers the freedom to choose and configure the right actuator each machine or production line needs.

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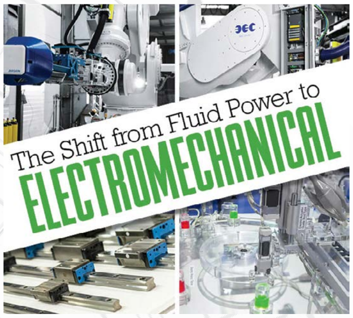
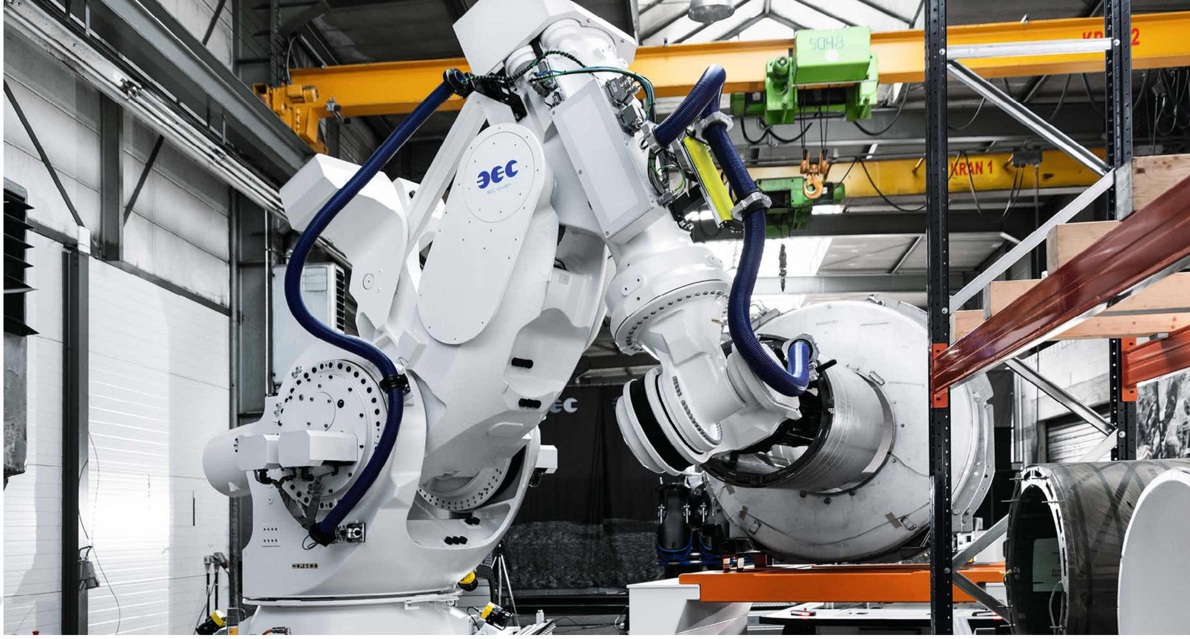




Festo

CHAPTER 5:

Electric Actuators Improve Robotic Assembly of MRI Machines

SARA JENSEN, Executive Editor, *Power & Motion*

Use of electric actuators in a robot gripper system provide the precise yet delicate touch required when assembling MRI machines.

Assembling magnetic resonance imaging (MRI) machines requires a high level of precision to be taken, particularly when inserting coils into the magnets used by these machines. Electric actuators from Festo have demonstrated their ability to provide the precision required when used in the grippers of robots employed to build MRI machines.

BEC GmbH — a developer of robotic systems for medical, industrial, and other applications — utilized Festo's EPCC electric actuators in the gripper system of its 2,300 kg load capacity articulated arm robot. With this robot, BEC's customer Siemens has been able to improve the assembly of its MRI machines while maintaining build quality.

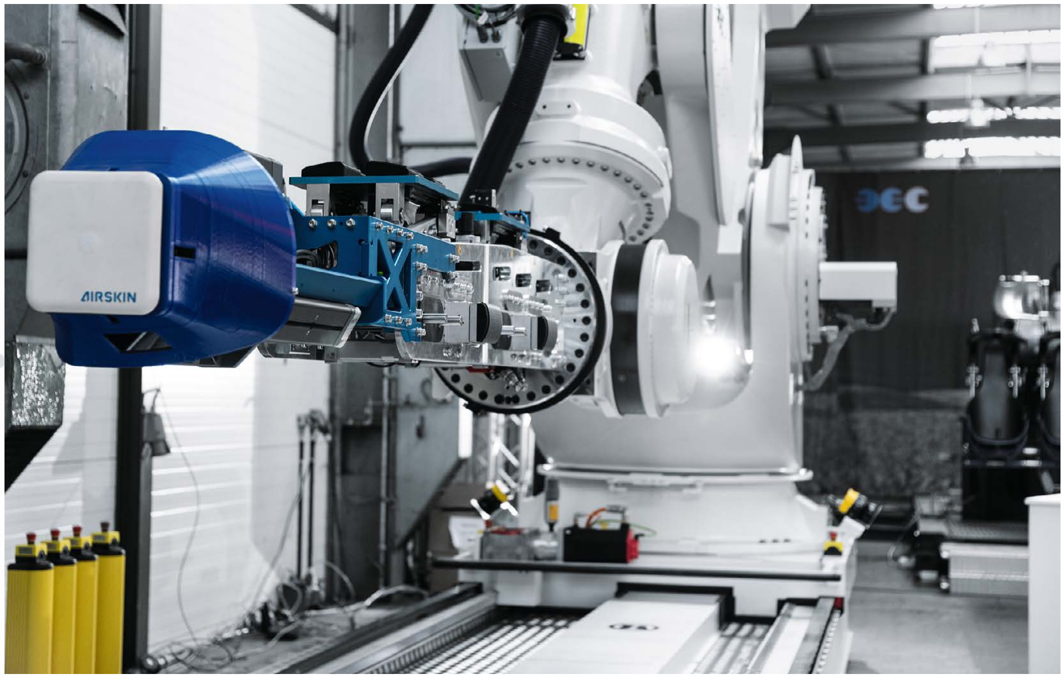
The Benefits of Electric Actuators

The gripper system mounted to BEC's articulated arm robot is equipped with 3D scanners, touch-sensitive Airskin sensors, and four supports driven by Festo EPCC electric actuators. Once picked up, the supports help to hold and insert coils—which can weigh up to 1.5 tonnes—into the MRI machine's magnets.

Hans-Günther Nusseck, project manager at BEC, said the utmost precision is required during this process. "It is vital that the coils do not twist or slip when the gripper picks them up and inserts them into the magnets," he said. "The tolerance for inserting the coils into the magnets is no more than 0.5 mm."

Not only must the supports be strong enough to hold the heavy coils, but they also have to do so without causing any damage. Because the force applied by the electric actuators can be adjusted as needed, they can better enable a strong yet gentle grip on the coils.

Use of the Festo electric actuators helped BEC achieve many of its design requirements when developing the gripper system for the Siemens robot. Electric actuators were chosen over pneumatics because of the application's need for free positioning and the actuators'



The high-tech gripper system on the BEC articulated arm robot includes electric actuators from Festo which ensure a firm yet gentle hold when inserting coils. Festo

ability to provide a strong yet gentle clamp which does not allow the coils to move, Festo explained to *Power & Motion*. Pneumatics would not be stiff enough to achieve the desired results in this application the company said.

The Festo EPCC electric actuators provide quieter, more precise positioning — a common benefit of electric versus pneumatic technologies. They also offer greater flexibility, a key benefit for this application. As the coil dimensions may vary from one machine build to another, the actuators must be able to adapt to different sizes which is easier to accomplish when using electric actuators.

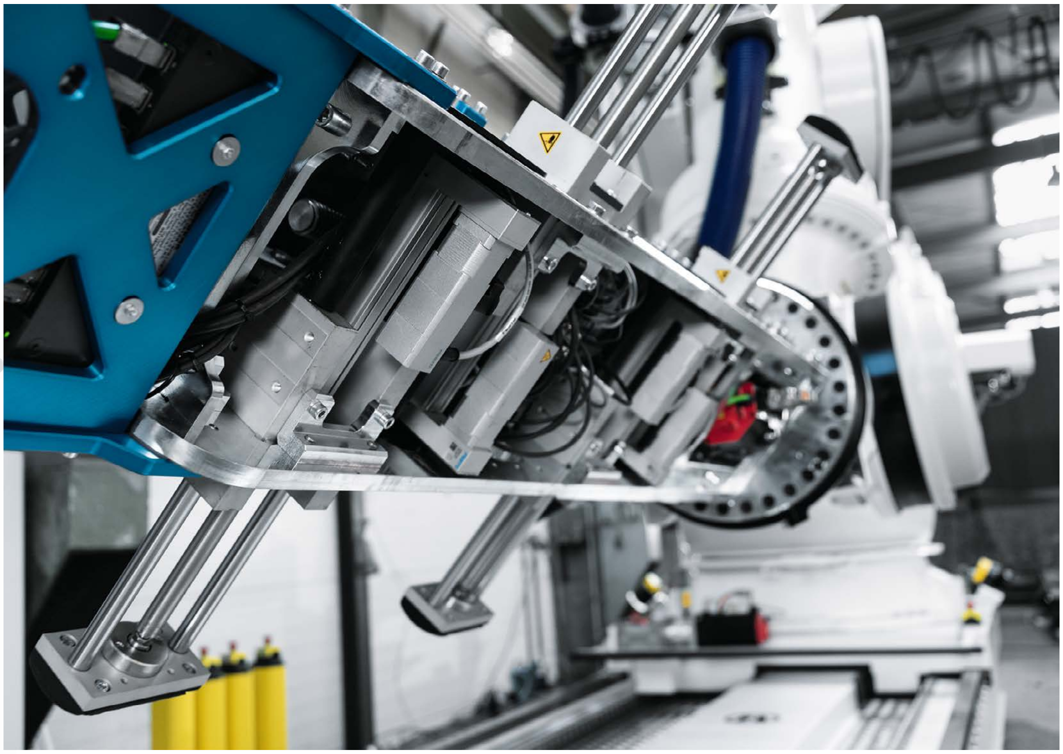
Additional design features which benefit the actuators' use in an application such as this include its low internal friction for short positioning times and high dynamic response, and strokes of up to 500 mm.

READ MORE: Robotics Spur Growth in Grippers and Suction Cups

The compact design of the actuator itself and the small space requirement of its drive were critical benefits provided by the Festo electric actuators as well. A compact ball screw drive enables a smaller package size as do the integrated coupling and double bearing. Flexible mounting of the motor in an axial or parallel position also aids space claim and can be changed whenever necessary.

READ MORE: Electric Actuation Mixes Precision and Efficiency

Festo's CMMT-ST servo drive is mounted on the robot instead of the gripper system reduces space requirements on the gripper and makes it less complicated. The servo drive has a PROFINET Interface for easy integration with existing PLCs used by Siemens



Festo electric actuators drive the supports used to hold and precisely place a coil within a magnet. Festo

while allowing the electric actuator to be controlled with a defined speed and limited force to meet application requirements said Festo.

READ MORE from Machine Design, an Endeavor Business Media partner site: Will the Robot Take my Job? A Roboticist Responds

BEC worked closely with Festo throughout the development process, starting at the design phase with dimensioning of the cylinder as well as support during integration with the customer's PLC. "We started working with Festo right from the initial phase of the project to make sure that the drives were designed, sized and commissioned efficiently and matched the overall system," said Nusseck.

Robot Improves Assembly Process

Siemens' use of the BEC articulated arm robot has made the work of inserting coils safer and more efficient. Human interaction during this portion of the MRI machine build is minimized due to the automation of many process steps.

Sensor technology integrated into the robot's gripper system allows it to move freely and safely without fear of harming human workers in the area as the sensors can immediately detect and mitigate these interactions. As such, Siemens was able to remove the safety fence around the robot and use its employees in a supervisory role during the coil insertion stage of the assembly process.

Working together with robots in this manner not only helps to keep workers safe but also frees them up to focus on other, more important work which requires their expertise and attention. Meanwhile, the robot can be used for more difficult work for which repeated precision may be required and could be hindered if done by humans.

"It is precisely this human-robot cooperation that we consider to be our unique selling point," concluded Nusseck.

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The servo drive for Festo electric actuators is mounted on the robot instead of the gripper system, reducing complexity and space claim. Festo