White Paper
June 2023

Are you truly maximizing the sustainability & productivity of your automation system?

Selecting the optimal motion control technology is key. Decide which technology is most effective for you.

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Pneumatic, Electric and Hybrid Automation Systems

Engineers are designing machines with automation systems that are more elegant and more sophisticated than ever before. They can improve the performance of factory automation applications, from production to warehousing and logistics. For example, advanced automation systems can increase accuracy in tire manufacturing lines, increase cycle times in automotive production lines and increase flexibility in packaging lines. The range of innovative motion control technologies that are available makes these solutions possible. When designing linear motion control systems, original equipment manufacturers (OEMs) depend most on pneumatic, electrical and hydraulic linear actuators. However, with innovations in these technologies, it can be difficult choosing between them when designing automation systems.

Historically, OEMs have had to choose only one of these technologies when designing automation systems. This has resulted in a decision process that includes evaluating an application's requirements, weighing the strengths of each technology and the benefits they provide, then selecting the technology that fulfilled the most important needs.

Focusing on pneumatic and electrical motion control solutions, the benefits of each of these two technologies may be seen by some as quite distinct: Robust pneumatics is understood to be easy to use and maintain, and electric motion is intelligent, fast and precise. However, that is not always the case. It can differ per application, environment and machine. Furthermore, for many applications, the chosen technology can only meet some but not every requirement. Some critical needs must be sacrificed in favor of others.

As machines, their processes and operational priorities have evolved over time, so has motion control technology. OEMs no longer have to choose between pneumatic and electric for an application. Hybrid automation systems combine the strengths of both technologies in complex motion control systems to maximize application benefits and minimize sacrifice.

While this level of innovation ultimately expands what is possible for industrial automation, it can also complicate specification and design. To choose motion control solutions that closely meet as many application requirements as possible and engineer optimal linear motion control systems, it's critical that OEMs consider their most pressing priorities and the key factors that address them.

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Manufacturers today are looking for more visibility and control over their machines and plants. The insights they can gain will help them to improve sustainability, overall equipment effectiveness (OEE) and productivity.

The Emergence of Hybrid Automation Systems in Response to Industry Trends

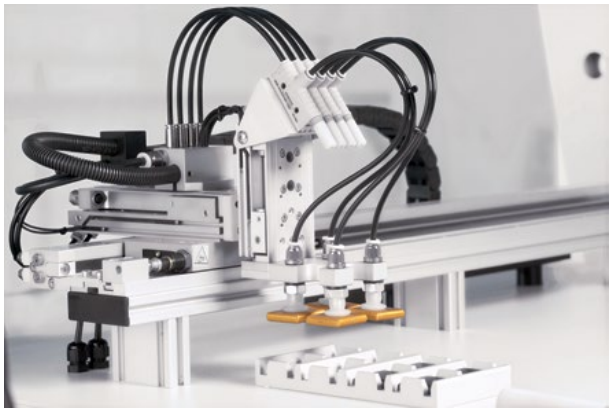
Advancements in machine design and shifting priorities have transformed manufacturing equipment and, in turn, motion control systems. Sustainability and competitive pressures have introduced new operational challenges, while digital transformation and evolving machine designs have added new expectations from the machines in production and packaging lines. For companies to remain competitive and meet their goals, these machines must maximize performance — with little room for sacrifice.
Hybrid automation systems have emerged in response to this changing landscape and are growing in popularity.

Sustainability is a top priority in every industry. The Paris Agreement set out a global framework to limit global warming to 1.5 °C (2.7 °F), and the world must halve emissions every decade until 2050 to meet this limit.

In response, companies have set ambitious net-zero goals and are seeking ways to reduce energy consumption and carbon emissions. Many industrial sustainability strategies include integrating to energy-efficient equipment.
To meet this demand, it's important that OEMs design motion control systems that use less energy and can be powered by renewable resources.

Environmental impact is not the only pressure today's companies are facing — they must do much more with much less. Labor shortages, skills gaps and supply chain issues are eroding the competitive edge companies have worked hard to gain, while customer demand is greater and more varied than ever. To meet demand and stay ahead of the competition, manufacturers must minimize machine downtime and maximize production. Hybrid automation solutions often connect to controllers and analytics software that provide valuable insights that can help empower

personnel and increase machine availability. Personnel can use this guidance to detect and address potential issues and optimize processes, improving overall equipment effectiveness (OEE) and productivity.



This level of visibility and control is made possible by the digital transformation of manufacturing facilities. Sensors and smart devices across the factory floor continuously monitor process parameters in real time, then send this data to controllers and analytics software to translate it into easy-to-understand, actionable information in the cloud. Operators can follow trends, receive diagnostic alerts and view automatic configuration in a dashboard and use this information to make informed decisions and act quickly when potential issues arise. Connected automation systems are a critical aspect of this vast ecosystem and give operators visibility and control that increase system uptime and optimize energy use, improving production and sustainability.

Another way manufacturers are increasing production is by installing compact, advanced equipment into their production lines. This allows more machines with greater capabilities to fit into the same amount of space. This greater capability often comes from sophisticated motion control systems, which make it possible for manufacturers to automate high-precision tasks from assembly to final product inspection. Motion control with better accuracy can prevent waste, shorter cycle times can increase output and greater position flexibility allows operators to change programs at the push of a button rather than by making time-consuming manual adjustments.

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Pneumatic

Fundamentals of Pneumatic Motion Control

Known for their robust operation, pneumatic solutions produce motion by using a compressed gas such as air or nitrogen to physically act on a mechanism. When most people think of pneumatic linear motion control, they think of a cylinder with an internal piston. This may be why pneumatics is often considered a discrete motion technology that can only fully extend or retract a mechanism. While this may have once been true, today's extensive range of pneumatic technologies can do far more.

Sophisticated pneumatic technologies can expand range of motion, provide operational visibility and insights, and offer greater control. Pneumatics can generate large forces and provide expansion force for airbags, provide air jets for cleaning parts and operate grippers for holding parts. Pneumatic accessories such as sensors and flow controls collect valuable data and make it possible for operators to continuously monitor and optimize operations and reduce waste.

Differential pressure controllers propel pneumatics beyond extension and retraction to continuous pneumatic positioning. This is accomplished by applying controlled pressure against a constant back pressure. Operators can control position manually using buttons and switches or automatically with a programmable logic controller (PLC). These devices usually operate relatively small electropneumatic on/off solenoid valves or modulating positioning valves that pressurize the pneumatic equipment.
Position switches or sensors may be added on the driven equipment to provide a closed-loop feedback signal to the controller.

Electric

Fundamentals of Electrical Motion Control

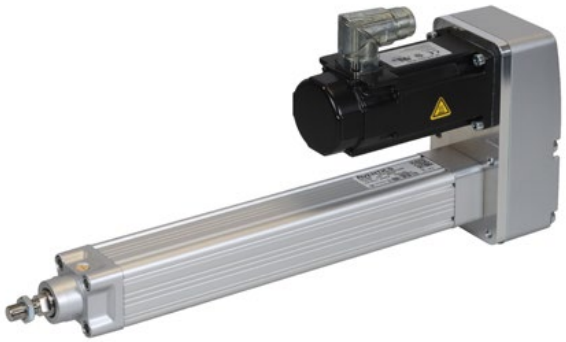
Electrical motion is produced by closed-loop systems that typically include a combination of electrical actuators, motion controller, servo drive, motor and feedback sensor. These servo systems convert electricity to achieve rotational or linear motion that delivers accurate positioning, precise angular velocities and variable acceleration profiles.

Unlike some motor designs that spin at a commanded speed, servo systems can provide a range of motion control and synchronization. The servo drive corresponds to a motor and follows commanded signals that communicate the specific function to fulfill.
This makes it possible for servo systems to provide motion control for complex applications such as robotic arms and continuously rotating conveyers.

When connected to edge controllers or PLCs, servo motion systems can perform even more advanced motion control and synchronization. These specialized functions include supremely accurate positioning with submicron repeatability, electronic camming and electronic gearing.

These specialized functions can benefit extremely complex applications, such as machining, robotics and manufacturing equipment. For example, a manufacturer can significantly reduce changeover time when upgrading a packaging line from mechanical cam discs to a servo motion system with electric cam discs.
Format changes using mechanical cam discs are complex, time consuming and subject to error.

In comparison, machine conversion using electric cam discs requires only the push of a button, saving time, improving accuracy, minimizing scrap and reducing costs.



Systems that include extremely versatile electric actuators that cover a wide range of application requirements, such as the AVENTICS™ Series SPRA Electric Rod Style Actuator from Emerson, offer manufacturers the highest levels of flexibility. SPRA actuators feature four sizes, multiple mounting options and three different screw technologies: a precision ball screw for exceptional durability and accuracy for applications that require high quality and throughput; a cost-effective lead screw; and roller screws for precision, speed and heavy loads.

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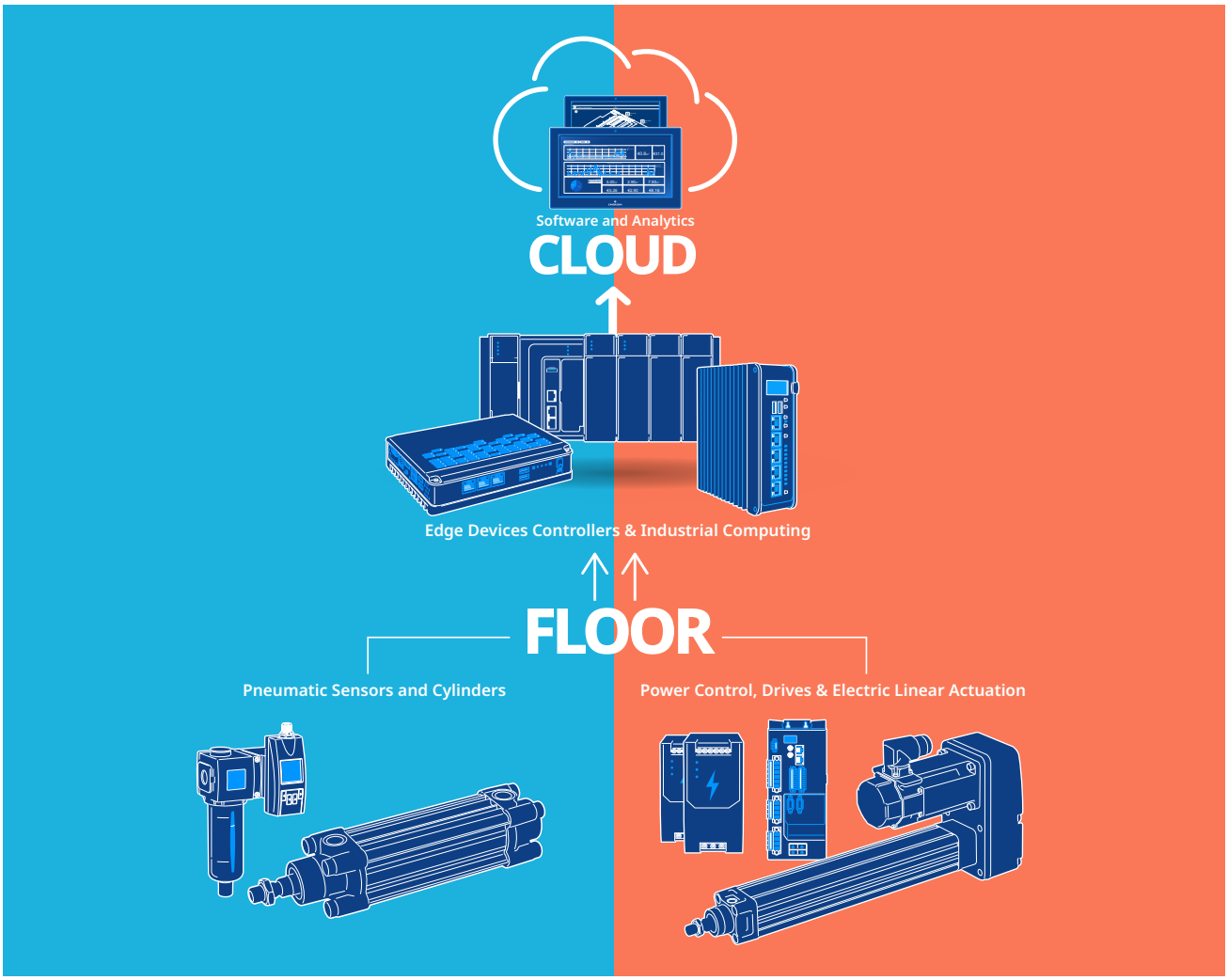

The Advantages of Hybrid Motion Control

Leading motion control technology suppliers like Emerson now offer integrated, full-solution packages that include pneumatic, electrical or hybrid motion control. The Floor to Cloud ™ solutions include intelligent devices, motion control, machine control and analytics.

Rather than choosing a single technology for an application, electropneumatic hybrid automation systems allow OEMs to apply appropriate technologies for each specific function. Many production and packaging lines include various types of OEM machinery, with product traveling between them along transport and accumulation conveyers. Different functions along these lines benefit from different technology.

Hybrid automation systems provide flexibility that allow OEMs to engineer equipment that can produce a range of products, minimize changeover time and meet evolving requirements over the system's lifetime. This supports manufacturers that face pressure to increase production while reducing costs by shortening production runs, increasing machine availability and extending equipment life. Motion control electronic reconfiguration allows operators to quickly change motion profiles, and some systems include future-ready features that can be implemented now or in later machine generations.

How To Select Optimal Motion Control Technology

With so many options available, it can be difficult to choose the most effective motion control solution for a system. When is it best to use pneumatic, electric or both technologies? There are many application factors to consider. For some applications, the technology or technologies that would benefit an application is quite clear. If boxes must be stopped, held or pushed off a conveyor, pneumatic cylinders are the best choice. If boxes must be moved to different lines or precisely positioned, an electrical actuator with multipositions is best.

If an application is more complex than these examples, it may benefit from a hybrid motion control solution. Consider a typical beverage packaging line. Its functions include stretch blow molding; filling and capping; conveying and accumulating; labeling; inspecting; and packing, palletizing and shrink-wrapping. Pneumatic motion best suits stretch blow molding, box folding and glue application, and servo motion best suits conveying and positioning products within filling and labeling equipment. Simple transport conveyers and palletizing systems, on the other hand, benefit from both pneumatic and electric motion. Electric motors can drive conveyers, and pneumatic actuation can control product stops and gates. Pneumatics can control bulk case handling while servo motion can control interpolation and fine position adjustments.

In addition to bottling, hybrid motion control benefits many other manufacturing applications. To seal air in filling applications, for example, electromechanical cylinders can use compressed air via a pneumatic connector. In assembly systems, an electric linear multiaxis system can use a pneumatic gripper. For weight compensation, an electric linear axis operating in vertical direction can use a pneumatic cylinder. By drawing on the complementary strengths of both pneumatic and electric motion technologies, this cross-technology automation makes it possible for OEMs to maximize the benefits of their automation systems and better support their customers.

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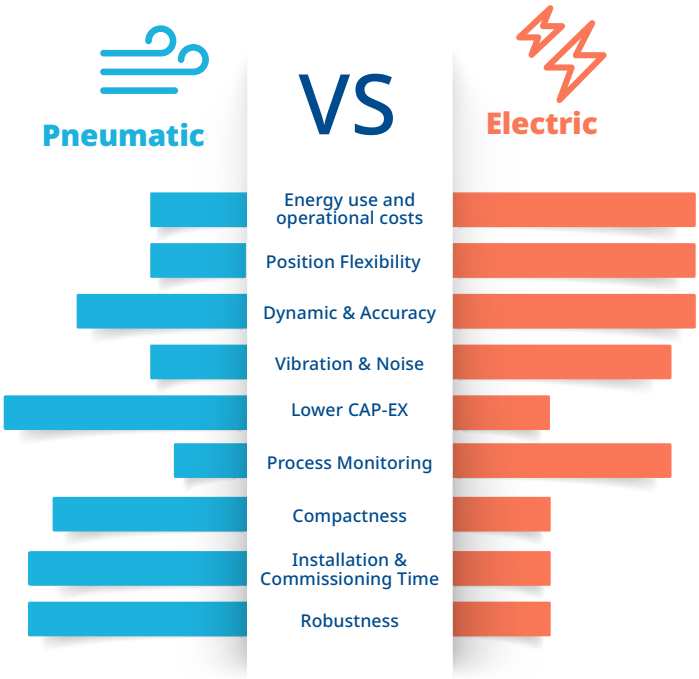
When selecting motion control technology, the following questions can help guide the decision-making process:



✓ **Is sustainability a priority?**

For companies to meet energy targets, it's important to consider how the motion control technology may affect the energy use of the machine and overall energy efficiency of a facility. Electrical motion is considered more energy-efficient than pneumatics. This is because pneumatics relies on the production of compressed air.

When cylinders move, they consume compressed air that cannot be reused, and cylinders with big diameters and/or high duty cycles can consume high amounts. Pneumatic systems can also experience compressed air leaks, which waste energy, and compressors often run regardless of cylinder operation. In comparison, electrical motion systems only use energy when parts are in motion, and the system can "recycle" the electrical energy when the actuator decelerates.

However, there are sophisticated sensors that make it possible to continuously monitor pneumatic systems in real time and reduce energy use. These sensors measure key parameters and detect leaks, helping manufacturers quickly address issues and optimize compressed air use.

Hybrid automation systems can enhance sustainability by improving overall machine efficiency and reducing scrap.
This reduces resource consumption and, in turn, operational costs.

✓ **Are operational costs a concern?**

If so, consider utility costs and periodic maintenance required over the life of the machine. The energy efficiency of electric motion control reduces energy costs, while its high precision can reduce scrap. The on-board digital capabilities of electrical motion control systems make it possible for operators to monitor device health and identify and address any issues before they become critical. This predictive maintenance increases unplanned downtime and reduces related costs.

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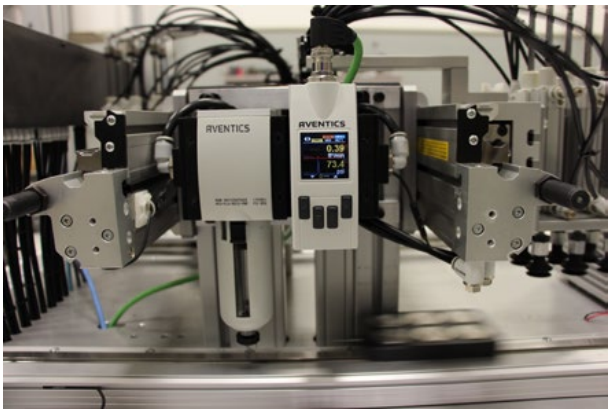
However, the addition of intelligent technologies such as smart sensors to pneumatic motion systems makes it possible to continuously monitor these systems in real time. The insights gained can help manufacturers reduce energy use and practice predictive maintenance:

✓ **Is position flexibility required?**

Electrical motion offers greater position flexibility than pneumatics. Servo motion functions include jogging, or controlled movement along an axis; homing, or moving an axis to a predefined "zero" position; indexing, or moving an axis to a predefined angle or spacing; and roll feed, or continuous product feeding with cutting to specific lengths.



The AVENTICS Series AF2 is a smart flow sensor that monitors air consumption in pneumatic systems, enabling rapid intervention in the event of leakage. This helps to optimize energy consumption and prevent machine downtime.

✓ **Does the application call for dynamic motion and high accuracy?**

If applications require fast speed, pinpoint precision and high efficiency, electrical motion control may be the best choice. The closed loop feedback between the controller and motor provides superior accuracy and repeatability while operating at high speeds and producing strong forces.

✓ **Are vibration and noise a concern?**

Electrical motion is quieter than pneumatics. In a pneumatic actuator, sound is produced by compressed air leaving the cylinder at high speed and the impact of the piston rod against the end cover if the actuator isn't cushioned properly. An electric actuator emits a much lower sound caused by the movement of the ball screw.

✓ **Is capital expense (CAP-EX) an issue?**

If budget is a primary concern, pneumatics may be a better choice than electrics. The overall capital expenditure costs for the hardware, design and installation of pneumatic motion solutions are typically lower than electrical motion solutions. There are some estimates that put it at 20% less per axis. Because there are fewer components to replace, upgrading pneumatic motion control solutions results in less replacement cost.

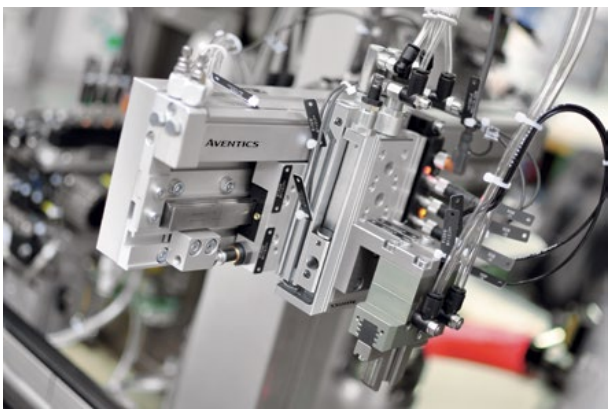
✓ **Are connectivity and process monitoring important?**

Both pneumatics and electronic motion technologies have industrial internet of things (IIoT) functionality, but servo controls offer deeper analytical capabilities for data-intensive applications. As microprocessor devices, servo drives and controllers have a high level of innate, on-board functionality and directly provide local and remote diagnostic and data logging features for dashboards. Values such as motor temperature and used motor current are readily available, which makes it easy to calculate precise lifetime expectancy for the actuator and display the requested exchange of the actuator to the operator. Smart pneumatics, on the other hand, require additional sensors to monitor compressed air flow and measure values.

Intelligent motion control helps manufacturers improve OEE, reduce downtime and increase productivity by allowing them to capture cylinder and actuator performance data and use it to gain insights.

These insights provide visibility into component health and can direct personnel to replace worn components before failure can occur.

Emerson Floor to Cloud solutions offer connectivity for both technologies. Integrated pneumatic motion control solutions include a pneumatic cylinder, valve system, controller, analytics software and dashboard via gateway, while integrated electrical motion control solutions include an electrical linear actuator, servo motor and drive, controller and dashboard via gateway.



An application example showing a compact pneumatic linear motion solution.

✓ **Is space at a premium?**

Pneumatic motion control systems tend to be more compact and include fewer components than electrical motion control designs, helping reduce overall equipment footprint. However, electrically driven machines can have higher throughput than pneumatically driven machines, which means fewer machines, and potentially less space, are required to produce the same output.

✓ **Installation and commissioning time**

If minimizing installation and commissioning time is a primary concern, pneumatics may be a better choice than electrics. Pneumatics are simple to design, install and maintain.

Servo motion solutions require more complex components, design practices and installation methods than pneumatic motion solutions. If OEMs must source components, match them and engineer systems themselves, a greater number of more complex components can make the process longer.

However, complete, integrated hybrid automation systems like those Emerson provides can also simplify installation and commissioning, as they are pre-engineered and assembled.

Additionally, pneumatic installations can be done by mechanical engineers, whereas electrical motion system installation requires a specialized application engineer. Mechanical engineers cannot set up electrical systems of 230 V AC, a common voltage for servo motors.

✓ **How aggressive is the environment?**

If durability is a requirement, pneumatics is the more robust technology. Pneumatic actuators can withstand shock and collision, even with high loads, and can maintain their loaded position for a long time.

In comparison, electric actuators have more complex structures, and their motors can be sensitive to vibration. They cannot withstand loads as high as pneumatic actuators can, nor can they hold position as long. In addition, electric linear axes and motors cannot withstand high temperatures (> 40 °C) and require cooling. They also have a low ingress protection (IP) rating, which means they are vulnerable to washdown procedures and in need of effective protection.

Applications Examples

Ensure Product Quality in Cheese Making

The robust nature of pneumatic motion control systems makes them ideal for some types of cheese production. In these applications, cheese must remain in tanks under high pressure for a few days. A pneumatic system can load plates and reliably protect position for the required duration.

Improve Packaging Productivity

The challenge: A beverage company was experiencing complex, error-prone and time-consuming format changes with their packaging machines, which used mechanical cam discs.

The solution: Emerson helped the company select and upgrade their machines with servo motion systems that feature electric cam discs.

The outcome: The new servo motion systems simplify format changes by allowing operators to convert machines at the touch of a button. This saves a significant amount of time, improves accuracy, minimizes scrap and reduces costs.

Optimize Tire Manufacturing

Uniformity testing during the finishing process of tire manufacturing determines the quality of a tire and is essential for driver safety. The tests are completed under a high load and subject to high traction forces.

Robust pneumatic cylinders and actuators provide repeatable, highly precise and reliable motion control and positional accuracy of transfers on the uniformity machine. This reduces machinery downtime and maximizes throughput, giving manufacturers a competitive edge.

Motion Control That Solves Manufacturer Challenges

Original equipment manufacturers have more options than ever when it comes to adding motion control to machines. Although OEMs were once limited to pneumatic or electrical linear motion for an application, continued automation system innovation makes it possible to incorporate both. By considering several factors, engineers can simplify the decision-making process when choosing the most effective motion control technology for their application.

A complete motion control package can help manufacturers reduce energy use, increase productivity, optimize operations and stay ahead in their industries. Leading technology suppliers like Emerson offer a range of advanced, integrated solutions that combine servo drives, motors and electric actuators, as well as pneumatics. By including hybrid automation systems in their machine designs, OEMs can better answer their customers' challenges and needs.

To choose the most effective automation systems that deliver maximum benefit, it's important to work with a factory automation expert that has a comprehensive, Floor to Cloud portfolio of solutions. They can help gain a full understanding of the needs of the application and identify a solution that optimizes performance and value. A critical consideration is precise component sizing. Proper component sizing can optimize overall machine design and minimize operating costs. If a pneumatic cylinder is one size too big, energy costs can increase by about 20%. This is also true of electric linear motion. If electric actuators are bigger than necessary, the improper sizing will extend across rest of the system — a bigger motor, a drive with higher current and cables with bigger diameters. It is essential to have a supplier that understands the real-world requirements of an application and dimensions the system accordingly.

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Pneumatic, Electric and Hybrid Automation Systems

Hybrid automation systems allow OEMs to pass along the full range of benefits to their customers rather than choose between key advantages. With precise, powerful linear movement, the agility to meet changing requirements and advanced insights that improve productivity and sustainability, manufacturers are well-equipped to overcome new and existing challenges and leave their competition behind.

Find out more by visiting
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