Automation NOTEBOOK®

Your guide to practical products, technologies and applications

Are Pneumatic Components Compatible?

Riada Solves Difficult Packaging Problem

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Go here to learn more about NITRA H-series compact cylinders.

**Prices as of June 2016. Check www.automationdirect.com for most current prices.*

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This digital issue of Automation Notebook gives you snapshots of some of our latest products. You'll find products from a variety of categories including, Pneumatics, PLCs, Tools, Sensors, Wire and Wiring Accessories. We've also added to our Process Control, Power, Motion Control, Enclosures, and Fuse product categories.

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Pneumatic Actuator vs. Electromechanical

In materials handling and assembly there are many ways to move an item from one location to another. Conveyors are one way and are widely used, but they can only move objects in a fixed path, limiting their use in more precise manufacturing applications. When more accuracy is required than a conveyor can deliver, such as when the part orientation or alignment needs to be changed, a pick-and-place system is often used. The most common pick-and-place systems employ either pneumatics or electromechanics, with hybrid electro-pneumatic systems also an option in some applications. The question then becomes what system is the best for each application, taking into consideration multiple factors including cost, complexity, performance and maintenance.

The main reasons are lower upfront and maintenance costs, which combine to make pneumatics the most popular and cost-effective choice for executing mechanical motion. While there are some, especially electric actuator vendors, who claim electric motion is better due to its superior energy efficiency, it's hard to beat the simplicity and reliability of pneumatics.

Picking the Right Pick-and-Place

In regards to complexity and performance, one should consider the amount of movement(s) that must be performed, the required accuracy of the placement, the weight of the objects to be lifted, the shape of the parts, and the distance they must travel. In general, jobs with complicated movements requiring a high level of accuracy need more expensive electromechanical pick-and-place systems. If the application has a fixed travel path and doesn't need repositioning or multiple positioning, a pneumatic pick-and-place system is often the best choice.

Hybrid systems use electrical components at the front end, and a pneumatic end effector to handle the part or object. These systems are more expensive than pneumatic solutions and less costly than electromechanical systems, and can be the best option for some applications as they combine the economy of pneumatics with the speed and accuracy of electromechanical systems.

When Pneumatic Pick-and-Place Systems are Better

Although initial cost is often the driving force for using pneumatic pick-and-place systems instead of electromechanical solutions, it's not the only reason, as seen in the Table below.

Advantages of Pneumatic Pick-and-Place Over Electromechanical Systems
• Much lower initial cost
• Higher force density
• More compact in most cases
• Use a safer energy source, compressed air as opposed to electricity
• Better for wet or corrosive areas
• Simpler installation, particularly with respect to programming
• Easier to maintain due to overall simpler operation
• Familiar learning method for younger students

Table 1: Advantages of Pneumatic Pick-and-Place Systems

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Pneumatic devices have a greater force density than many electromechanical solutions, which enables them to be a smaller and lighter, lowering space needs and energy costs. They can also be installed without complex components like controllers, as their operation is simpler with a single path of travel. In applications with contaminates, such as possible splashes, electromechanical systems pose more danger and are more likely to fail. Furthermore, electromechanical pick-and-place systems for these types of applications usually require specialized certifications and have a relatively small pool of vendors, thus making them quite expensive.

Pneumatic systems are not only safer in wet or corrosive environments, they can also withstand numerous cleanings. The pneumatic devices can be mounted close to the process while the associated electronics are housed in a cabinet well away from possible damage, simplifying installation and maintenance. Moreover, since controls for a pneumatic system are typically smaller than servo drives, internal space requirements in the control cabinet are reduced.

Build or Buy?

When the decision is made to implement a pneumatic system, the next choice is to buy an off-the-shelf system or to build one using cylinders, valves and end effectors. A preconfigured system will be in operation faster as it comes with all components pre-assembled and tested. Designing and building a custom system will take more time up front, will cost less in terms of purchased parts and will result in an optimal fit for the application.

Custom pneumatic pick-and-place systems can be built in a variety of configurations using standard components, which are assembled to produce different linear and rotary motion actions. A basic system can be built using primarily off-the-shelf components at a very reasonable cost. Nevertheless, designing a pick-and-place system requires a certain amount of engineering skill.

Pneumatic pick-and-place systems rely on cylinders for mechanical movement in either a linear or rotary direction. Round body cylinders are the least expensive option but they require mechanical guides that are usually custom machined for the particular application. As such, they may be the best choice for a company that can perform machining in-house. For those without in-house machining capabilities, guided-rod extruded-body cylinders are a good choice even though they can be up to five times as expensive as their round body counterparts.

Rotary actuators are used with cylinders to perform non-linear, twisting movements; they can flip,

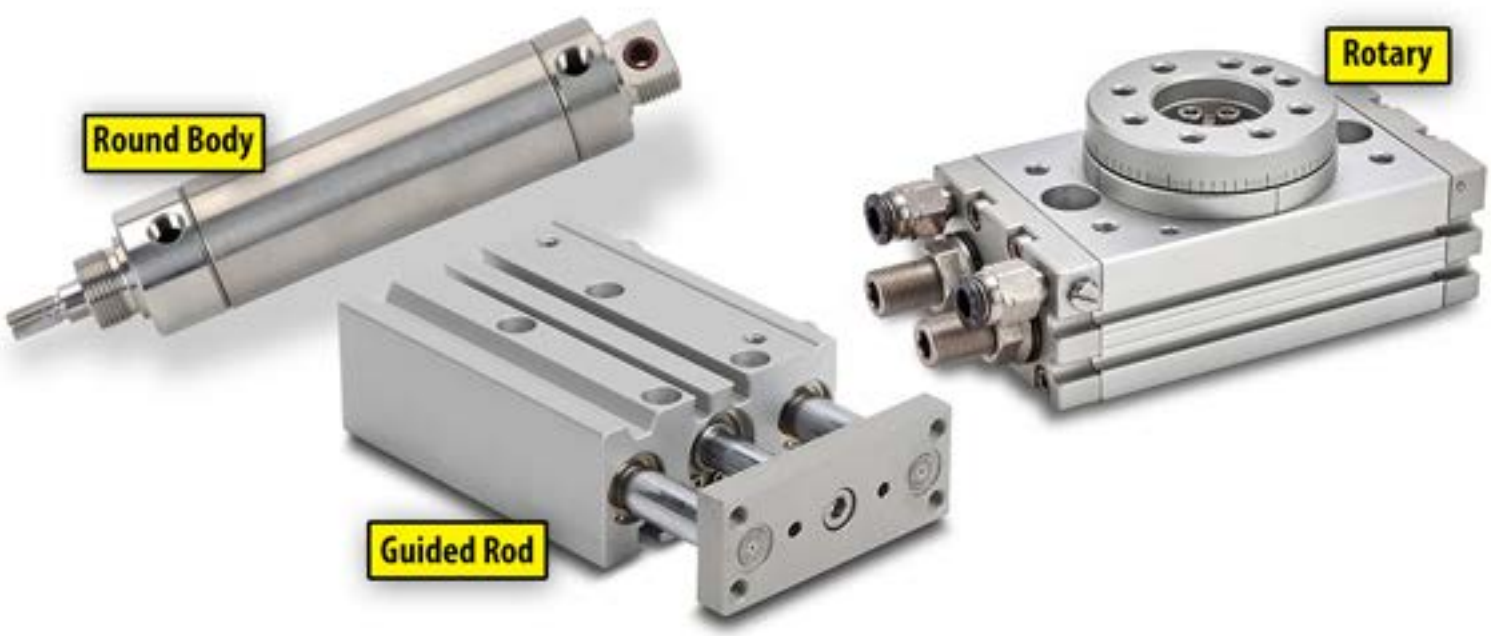

Figure 1: Guided cylinders can simplify installation in a pick-and-place application

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tilt or turn a part or an object. For example, a rotary actuator is used on one end of a vertical axis, with a gripper on the other end. This enables the actuator to move parts in an arc motion, instead of moving the object up and across in separate movements. It should be noted these actuators typically don't rotate more than 270 degrees.

Readily available pneumatic cylinders are generally limited to about 2500 pounds of available thrust, but multiple cylinders can be combined into a very powerful pick-and-place system. These cylinders and other components come in a wide range of materials: nickel-plated brass, aluminum, steel and stainless steel. Designers should select the appropriate material depending on loads, environmental conditions and cost constraints.

Stroke Length Considerations

The stroke length determines how far the pneumatic device can move. Single-acting cylinders have limited extension resulting from the space needed for the compressed spring. Therefore, single-acting cylinders are best suited for applications that only need approximately 6 inches (150 millimeters) of stroke length or less.

Since double-acting cylinders don't use a spring return, stroke lengths for this design are generally available up to 24 inches (600 mm) in most popular bore sizes. For travel distances longer than 24 inches, there are a number of different rodless cylinder designs that work very well in pick-and-place systems.

Speed Control Concerns

While pneumatic pick-and-place doesn't offer the speed control and wide range of motion found with electromechanical systems, they can deliver an often acceptable level of speed control by using valves. Flow control or needle valves are used to control the speed of the pneumatic pick-and-place device by regulating the air flow to the actuator. Overall system sizing of valves, tubing and actuators will have an effect on achievable speed range, and greater care should be used if speed is critical.

Grippers and Vacuum Device Deployment

The end effector that picks up the object in a pick-and-place system can be pneumatic grippers or vacuum suction cups both of which are usually lighter, smaller and less expensive than electric grippers.

Pneumatic grippers work well for applications requiring high speeds or a high gripping force. While they don't offer the force and positioning attributes of electric grippers, pneumatic grippers can be adjusted by using a control valve or an analog proportional pressure valve to change pressure and thus gripping force.

The initial cost of suction cups is low, and they come in a variety of sizes. Suction cups are a good choice for delicate products, such as food and glass, and for flat objects like paper and sheets of

Figure 2: Pneumatic powered options for placing product

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metal. While they work for some high-intensity applications, the operational cost of the required vacuum generators may be prohibitive for systems with just a few cups. For inexperienced users, suction cups can also be tricky to implement. Selecting the right size and amount of suction is often more of an art than a science, and determining the size and suction of the cups is often an exercise in trial and error unless considerable experience has been gained in similar applications.

Reducing Total Cost of Ownership

One of the complaints about pneumatic pick-and-place is relatively high operating costs compared to electromechanical systems because they use compressed air. Most pick-and-place systems will operate in settings where compressed air is already being used for other purposes, and several steps can be taken to mitigate air usage. One way to reduce costs is by mounting the pneumatic control components near the point of operation to minimize air line lengths. Locating the valving close to the actuators and using appropriate cylinder and valve combinations can reduce the required air volume by up to 35 percent. In addition, using modern components that are made to reduce leakage and utilizing improved lubricants that operate across a wider temperature range, will extend the life of actuators and valves in your system which in turn reduces the costs of maintenance and replacement. If you would like more tips on making your pneumatic system energy efficient, see this Energy Efficient Pneumatics article.

The Choice is Yours

There are some misconceptions and outdated ideas about pneumatics that can needlessly drive up the cost of pick-and-place by relegating users to higher priced electromechanical systems. When just two positions per axis of motion are required, and when very high speed and extreme precision aren't required, pneumatic pick-and-place systems will usually be a simpler and less expensive option. And while pneumatic pick-and-place systems have been used for decades, over time they have been improved with technological advances making these time-tested systems a viable choice for many applications.

Are Pneumatic Components Compatible?

The industrial pneumatics market is fairly mature. While there continues to be new developments and technologies, many of the tried and true core products have been around for years. One advantage that this can offer to both system designers and end users is often having several brands of pneumatic components that are interchangeable with each other. This can allow users the opportunity to shop around and look at more than one supplier for the same component.

Pneumatic Components Cross Reference Guide

Competition is almost always beneficial to customers because now factors such as price, availability and service can be considered along with performance when making a buying decision. Check out our Interactive Cross Reference Chart here for a list of vendor components that are comparable to our NITRA Pneumatics line.

Here are examples of a few components that have interchangeable sources:

Non-repairable Air Cylinders

Type	Mount	Bore	Stroke	NITRA PNEUMATICS (AutomationDirect)	Bimba	Norgren	Parker
Double Acting	Pivot	3/4″	6″	A12060DP	046-DP	RLC06A-DAP-AA00	0.75DPSRx6.0
Single Acting	Nose	7/8″	3″	A14030SN	063	—	0.88NSRx3.0
Double Acting	Double End	1-1/4″	10″	A20100DD	1210-DP	RLE10A-DAD-AA00	1.25PSRx10.0

Table 1: Examples of components that have interchangeable sources.

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Pipeline Valves

Pipeline Valves	Normal State w/o power applied	Thread Size	Control Voltage	NITRA PNEUMATICS (AutomationDirect)	ASCO
2-way direct acting solenoid valve	normally closed	1/4" NPT	24VDC	DVP-3DC2E-24D	8262H007
2-way direct acting solenoid valve	normally closed	3/8" NPT	120VAC	DVP-3DC3F-120A	8263H232
2-way diaphragm solenoid valve	normally closed	1" NPT	120VAC	DVD-2BC6F-120A	8215B050
2-way stackable solenoid valve	normally closed	1/8" NPT	120VAC	DVP-2CC1C-120A	8280B002
2-way stackable solenoid valve	normally closed	1/8" NPT	120VAC	DVP-2CC1C-120A	8280B002

Table 2: Pipeline Valves.

Care must be taken when changing brands to verify any possible differences in performance or dimensions. If you can adapt to some small differences, however, you may often be able to find a less expensive or more readily available component to do the same job as your current one.

Compact Extruded Body Cylinders:
100mm bore, 100mm stroke, magnetic piston
AutomationDirect: H100M100MD-M
Fabco-Air: GND-SA100X100DB
MFD Pneumatics: MACQ-100X100-S-T
Numatics: UND-SA100-100D-B
Parker: S100DC7G0100
SMC: CDQ2A100TN-100DZ

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Riada Solves Difficult Packaging Problem

When selecting the right shampoo, what factors do you consider? Scent, ingredients, cost? How about packaging? That's right, packaging. For the follicly-challenged, like myself, packaging may be a real decision maker. After all, luster, sheen and volumizing abilities are kinda' lost on me. For most, packaging is an afterthought, if it is a thought at all. But packaging can be the most complicated aspect of the manufacturing process. One that can require specialized machines customized to a particular product design. And that's exactly where Riada Equipment stands out. Based out of Winder, GA, Riada has been solving problems for cleaning product, food and beverage, textile, cosmetic, lubricant, and glue and adhesive customers since 1984. The company offers new bottling equipment, and also remanufactures existing customer equipment.

When asked where the exotic company name came from, owner Ross Adair said it was just his last name turned backward. How clever. When a long-time customer ran across a difficult bottling application, they turned to Riada to solve it, calling on that very cleverness.

The difficulty in this particular customer's case centered on uniquely-shaped shampoo bottles. The oval containers precluded stacking, and also conveying bottle-to-bottle. Instead, each bottle had to be indexed and then clamped individually for the filling sequence. To accomplish this, Riada decided to use a programmable logic controller and associated system components from AutomationDirect.

Controlling Machine Motion

The machine entry section consists of a set of DC motor-controlled round spacing wheels that move the bottles onto the machine belt conveyor for filling. Running at a speed slightly less than the belt conveyor, the feed wheels space the bottles at the correct distance for the fill nozzles and bottle clamps. The belt conveyor speed is regulated by an AutomationDirect GS 2 series AC drive.

Round-body style entry and exit pneumatic gate cylinders are also supplied by AutomationDirect, and they control the overall 10-bottle group container flow into the machine, and out of the machine to downstream operations.

As the bottles enter the machine, they are counted by an MVP series retro-reflective photo eye. If the machine is set up for a ten-bottle run, then ten bottles are counted on the way in or the cycle is halted. The bottle count is decremented as bottles exit the machine, and the machine cycle is halted if the total count doesn't reach zero.

A set of NITRA brand E-Series rod-guided pneumatic cylinders is located at each of the ten fill stations and is used to clamp and hold the bottles. This dual-rod

continued >>

design translates the force of the air into precise linear motion and minimizes any side-to-side movement. This is critical to the clamping sequence as it minimizes clamp-settling time.

An MV2-series photo-eye at each station individually detects the presence of a bottle and controls the clamping sequence. Since space in the dispensing area is at a premium, the MV2 diffuse type photo eye was used at each station to sense the presence of a bottle. This type of sensor eliminates the need to mount either a reflector or receiver on the other side of the sensing line.

NITRA pneumatic equipment is prevalent throughout the machine. An AFR series filter-regulator provides the machine with clean air at the right pressure, and Riada added a 3rd party receiver tank to provide excess capacity and minimize any drops in air pressure regardless of the real-time air load, ensuring consistent cycle times.

Manifold-mounted NITRA AVS-5 series 5-port 4-way solenoid valves provide the air control function required by the double-acting pneumatic cylinders. MLA series air header manifolds were added at the machine front and rear to distribute air with minimum piping runs, with the result being higher air pressure and more consistent cycle times.

Dispensing Operations

Filling the customer's containers with product is the primary job of the machine. All equipment with surfaces touching the product meets FDA specification, including the stainless steel metering cylinders, and the shut-off stopper cylinders at each nozzle.

Supplying the force to move those cylinders are D-series NFPA tie rod cylinders. At the rear face of each tie rod cylinder are threaded rods and handles. Each rod travels through customer-supplied holes, and penetrates the rear face of the tie rod cylinder to provide a stop for its piston.

Manually adjusting the rod length varies the stroke of the tie rod cylinder, which in turn varies the volume dispensed by the stainless cylinder, a very simple yet effective design. Different color pressure and exhaust tubing separates the lines to facilitate tracing for troubleshooting.

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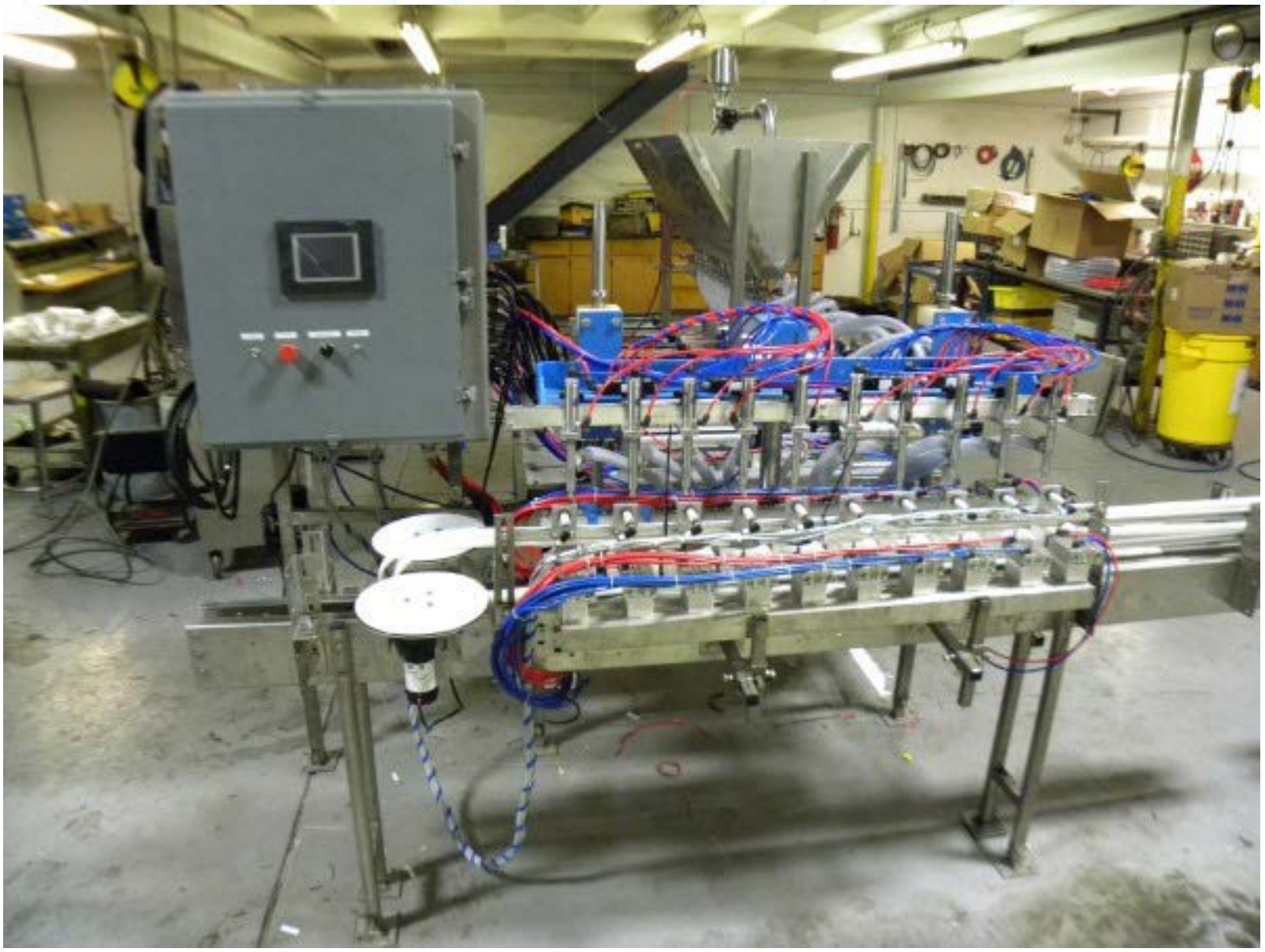

Control and Operator Interface

The entire machine sequence is controlled by a DirectLogic DL-06 programmable logic controller. This brick style unit contains both the CPU and sufficient I/O to meet the machine requirements. A six-inch EA9 series color touch-screen C-more human-machine interface (HMI) allows for flexible machine product and cycle time setup. The HMI is used to set up various timers and variables for the filling process.

It's also used to control machine start and stop, minimizing the need for pushbuttons.

Besides operating screens, a maintenance screen is included. This screen allows operators to run the machine dry for testing various components and operations. Typical dry runs include clamping and unclamping of bottles, raising and lowering fill heads, and running the machine through its entire sequence without dispensing any product.

Test and Results

Shop test was performed at the Riada facility in Winder, Georgia. Minor PLC program changes during shop test were done remotely by Riada's systems integrator, Systems & Controls

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of Lenoir City, TN. The integrator's PC was connected remotely to Riada's shop floor PC running DirectLogic programming software. The connection was made over a wireless plant network at the Winder location. Successful shop test and product run-off with the customer allowed Riada to receive final sign-off prior to shipment, a critical milestone. The machine has been running for two shifts a day since November 2014 without interruption. Due to these successful results, the customer ordered and Riada delivered clamping systems for two of the customer's existing machines.

Pneumatic Circuit Symbols Explained

Directional air control valves are the building blocks of pneumatic control. Pneumatic circuit symbols representing these valves provide detailed information about the valve they represent. Symbols show the methods of actuation, the number of positions, the flow paths and the number of ports. Here is a brief breakdown of how to read a symbol.

Valve Symbols

Most valve symbols have three parts (see Figure 1 below). The Actuators are the mechanisms which cause the valve to shift from one position to another.

The Position and Flow Boxes indicate how the valve functions. Every valve has at least two positions and each position has one or more flow paths, thus every valve symbol has at least two Flow Boxes to describe those paths. Check out our Interactive Pneumatic Circuit Symbols here.

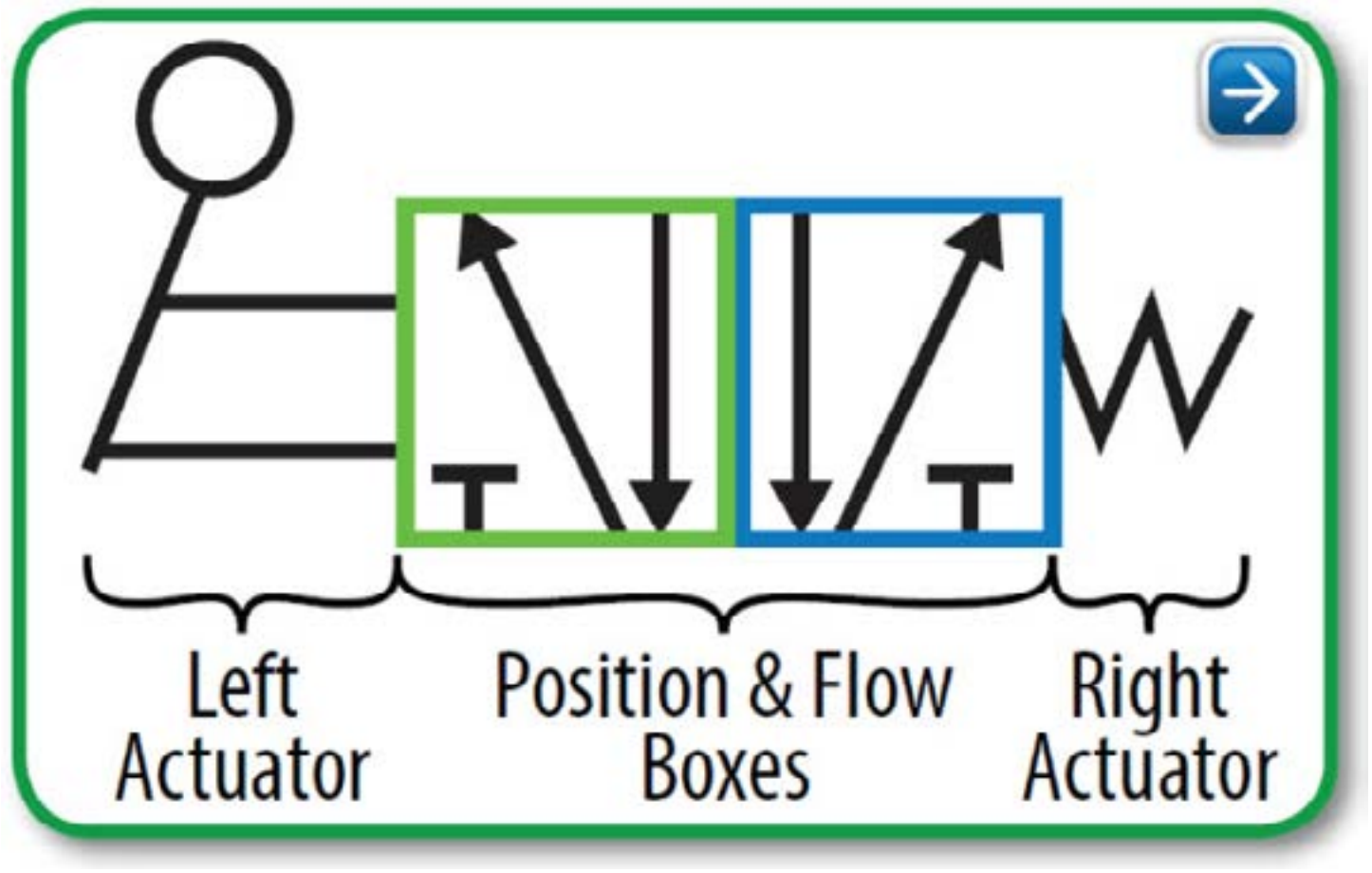

Figure 1: 2-position, lever actuated, spring return valve.

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Position and Flow Boxes

The number of 'position and flow boxes' that make up a valve symbol indicate the number of valve positions. Flow direction is indicated by the arrows in each box. These arrows represent the flow paths the valve provides when it is in each position.

The Flow Box next to the 'active' actuator always shows the current flow path(s) of the valve. In Figure 1, when the lever is NOT being activated, the spring return actuator (right side) is controlling the valve, and the box adjacent to the spring shows the flow path. When the lever IS actuated, the box next to the lever shows the flow path of the valve. A valve can only be in one position at a given time.

In Figure 2 (a 3-position valve), the valve has both solenoids and 'spring return' actuators on both sides, the spring return actuators will return the valve to the center position but only IF neither of the solenoids is active:

With this 3-position valve, the center flow box shows the flow path when neither actuator is active and the springs are holding the valve in the center position. In this fairly common example, the center box indicates that there will be no air flow (and the associated cylinder won't move) unless one of the two actuators is active. This type of valve can thus be used to "bump" or "inch" a cylinder incrementally along its extension or retraction stroke for various purposes.

continued >>

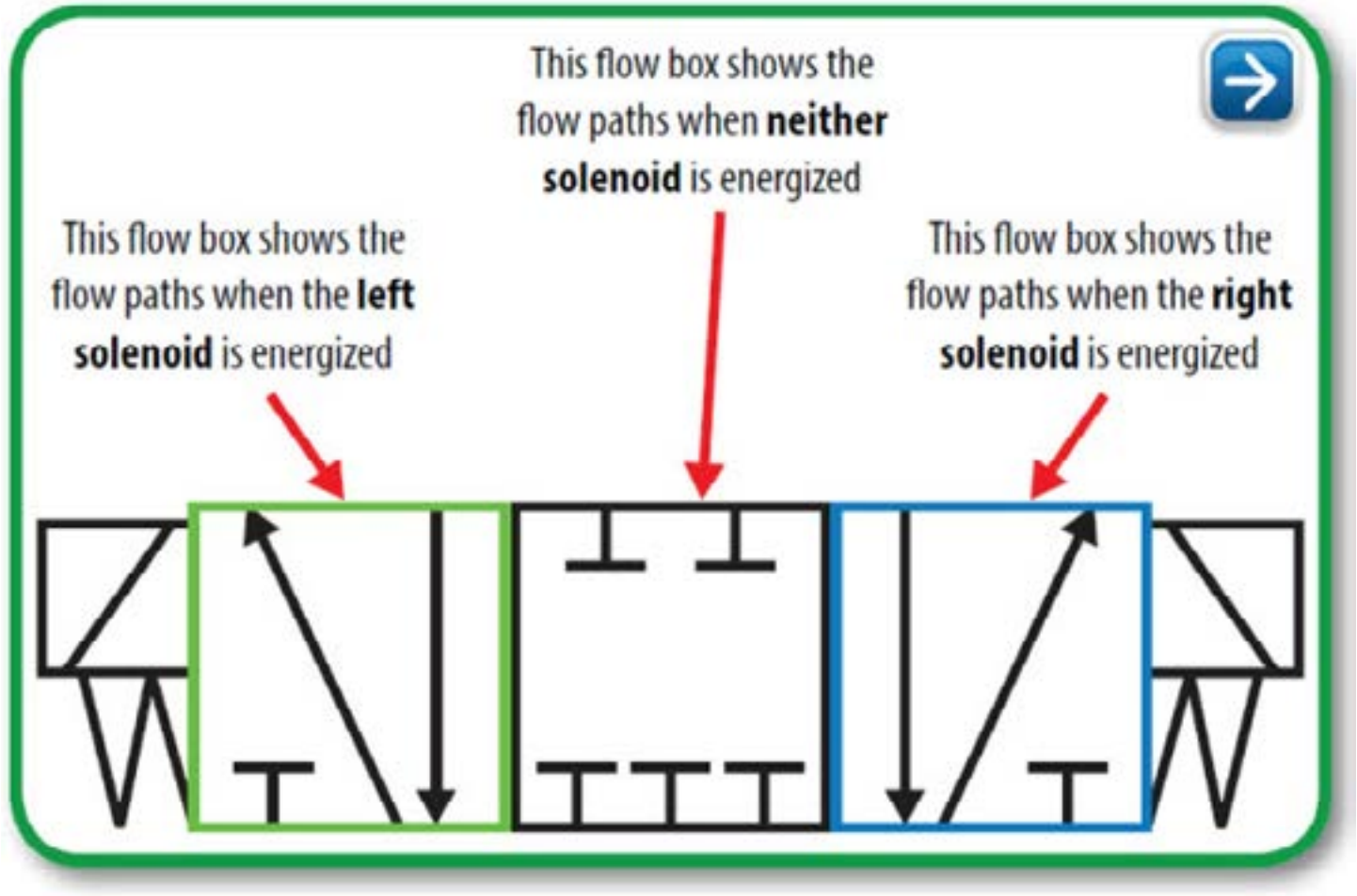

Figure 2: 3-position, double solenoid actuated, spring return valve.

Ports

The number of ports is shown by the number of end points in a given box. Count only the ports in one flow box per symbol (For example there are three boxes in the Figure 2 valve symbol showing each of the three different positions possible for the valve). In Figure 3, there are a total of 5 ports. Sometimes a port (usually an exhaust port) goes directly to atmosphere and there is no mechanical means for attachment of silencers, flow control valves, or any other accessories. To indicate this (in some flow diagrams), ports with attachment capability will have a short line extending beyond the box (as shown on ports 1, 2, & 4), while the ports you cannot attach to will not have the external line segment (ports 3 & 5 in this example).

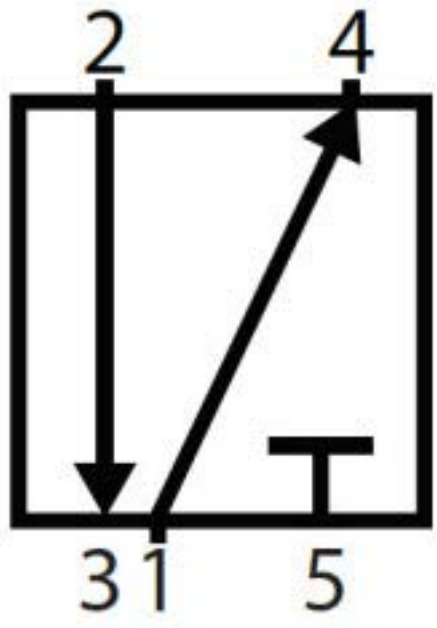

Figure 3: 5-port valve

Port Labeling

Port labels are typically shown on a single flow box per symbol. Different manufacturers label valve ports with different letters, but the labels at right are fairly standard. "P" represents the pressure inlet port, "A" and "B" are outlets (generally plumbed to the 'extend' and 'retract' ports on a cylinder), and "R" and "S" indicate the exhaust ports.

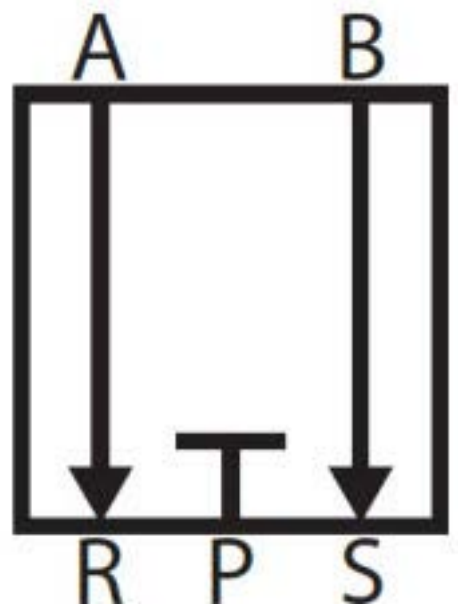

Figure 4: Port Labeling

Ports vs "Ways"

Valves are often referred to by their number of ports, and also by the number of "ways" that air can enter or exit the valve. In most situations the number of ports and ways are the same for a given valve, but take a look at Figure 3 above.

It has five ports, but it is considered a 4-way valve because two of the ports share the same exhaust function. This is a holdover from hydraulics – where the two exhaust paths are joined (internally to the valve), so that only one return port is required, and only one return line is required to get the hydraulic oil back to the storage tank for re-use. In other words, in a pneumatic system the two exhaust ports (R and S in Figure 4) are only counted as a single "way" since they both connect the valve to the same place (atmosphere). In the case of our pneumatic valve with similar functionality, the separate exhaust ports are created for mechanical simplicity (and as a cost saving measure), but they are not considered distinct "ways".

The symbols on the next page detail many of the ports, ways, and positions of common pneumatic valves. The specification for "ways" can be somewhat tricky; analyzing the circuit symbols is a better method for verifying that a given valve offers the required functionality.

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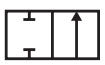
Common Valves and Actuator Symbols

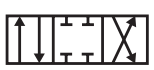
Directional Control Valve Symbols


2-position, 2-way, 2 ported


2-position, 3-way, 3 ported

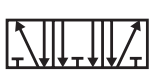

2-position, 4-way, 4 ported


2-position, 4-way, 5 ported

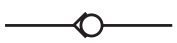

3-position, 4-way, 4 ported Closed Center


3-position, 4-way, 5 ported Closed Center

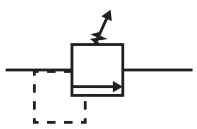

3-position, 4-way, 5 ported Pressure Center


3-position, 4-way, 5 ported Open Center

Simple Pneumatic Valves


Check Valve

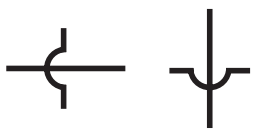

Flow Contol

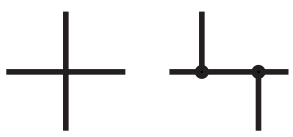

Relief Valve

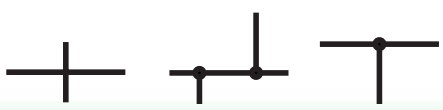
Lines

Main Line

Pilot Line

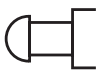

Lines Crossing


Lines Joined


Lines Joined

Actuator Symbols


Manual


Push Button


Lever


Foot Operated

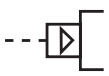

Mechanical

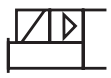

Spring


Detent


Solenoid


Internal Pilot


External Pilot


Piloted Solenoid with Manual Override


Lever Operated, Spring Return

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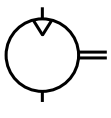
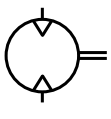
Other Pneumatic Circuit Symbols

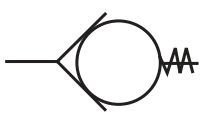
Other pneumatic components also have schematics or symbols, but these generally do not require as much explanation as those for the valves. Here are symbols for other commonly used pneumatic devices: Check out our Interactive Pneumatic Circuit Symbols here.

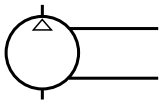

Accumulator


Air Dryer

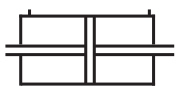

Air Motor (One Direction Flow)

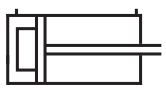

Air Motor (Two Direction Flow)

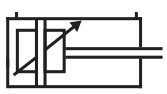

Check Valve (Spring Loaded)

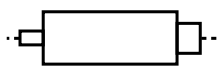

Compressor


Cylinder (Spring Return)


Cylinder Double Acting (Double Rod)


Cylinder Double Acting (Single fixed cushion)


Cylinder Double Acting (Two adjustable cushions)


Differential Pressure

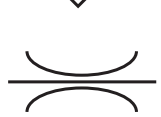

Direction of Flow

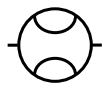
Exhaust Line or Control Line


Filter


Filter (Automatic Drain)


Filter (Manual Drain)


Fixed Restriction


Air Motor (Two Direction Flow)


Lubricator

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The capstone senior design project is the crowning achievement for seniors at the University of Connecticut School of Engineering. In this two-semester course, senior students are mentored by faculty and industry engineers as they work to solve real-world engineering problems for their corporate sponsor. Students learn about the principles of design, how ethics affect engineering decisions, how professionals communicate ideas, and the day-to-day implications of intellectual property.

Design Team Wins 1st Place at UConn Engineering Demo Day 2016

A student team of three graduating seniors, Jon Sobanski, Gary Basile, and Tashi McSweeny, recently completed their capstone project. They were mentored by faculty advisor Dr. Vito Moreno, and sponsor advisor Donald Scott. The project involved designing and building a machine to automatically tape parts for global aerospace supplier, PAS Technologies. PAS Technologies uses a chemical resistant tape to mask cylindrical parts in order to selectively coat regions during plating and anodizing processes.

Prior to the completion of this project, all of the tape application and masking was done by hand. This has multiple drawbacks, including long cycle times, poor repeatability, and ergonomic issues for the workers. Ideally, PAS Technologies wanted a process that was fully automated, required little human intervention, was highly adaptable to different part geometries, and most importantly was safe during operation.

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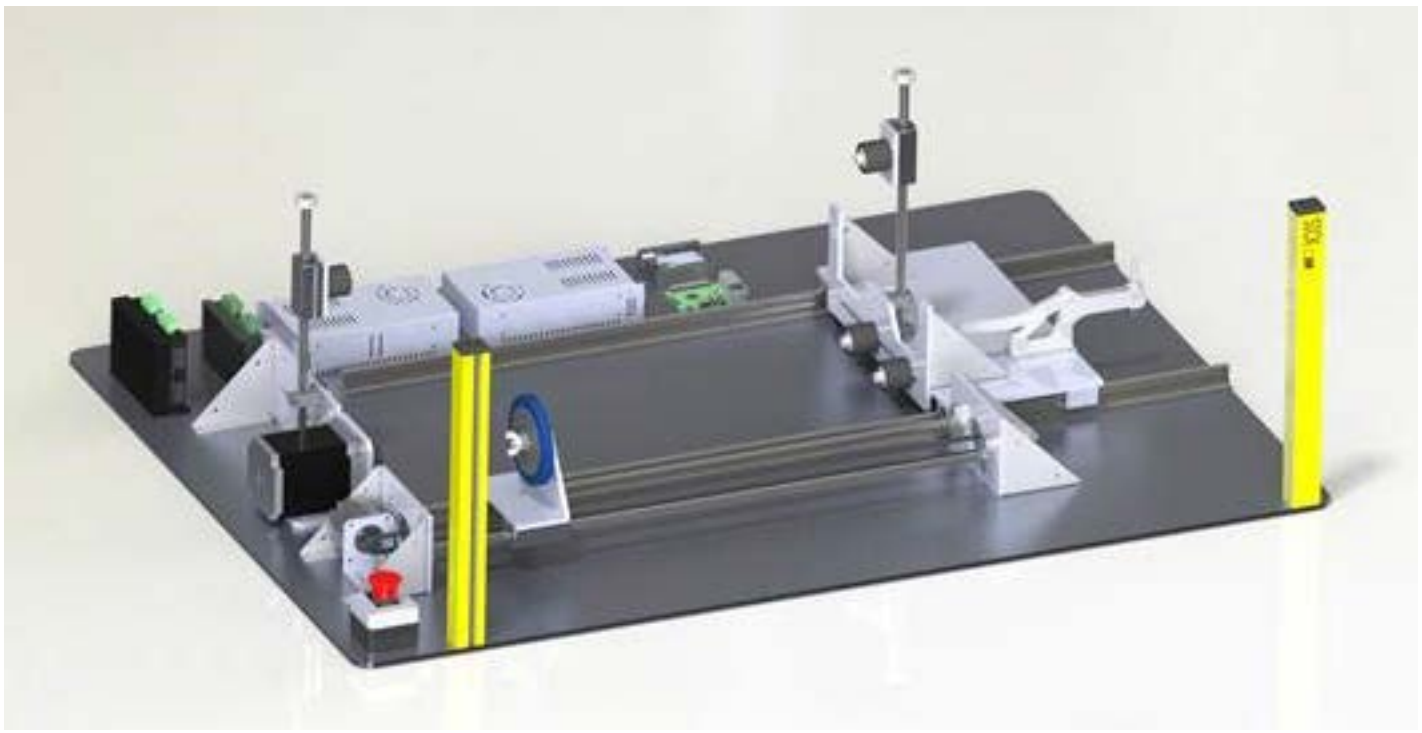

Design Requirements

Sobanski detailed the team's expectations: "The two main goals of the project were to develop an automated process that improves cycle time and reduces ergonomic strain on the operator. We also wanted the process to be more efficient in terms of part flow, operator movement and part storage. And lastly we wanted to be able to accommodate a wide variety of cylindrical parts, as well as alternate types of tapes used for the various taping processes."

The machine also had to be able to tape high-value aerospace components without any damage to the part. Each PAS Technologies location typically takes in an average of 200-250 parts per day for tape treatment. Around 65% of the parts are considered small (6" diameter or less) and take around two to four minutes per part to prepare by hand. The larger parts (6" diameter and up) cover the remaining 35%, and take approximately 15 minutes to tape completely. The machine is designed to accept two different types of tape: non-adhesive Sequoia GSV-1 and a variety with a 3M adhesive. The machine has to be able to tape over each section of the part with a minimum of 2 layers of tape, ensuring complete coverage of areas where plating or anodizing is unwanted. A poor application could result in rupture or failure of the tape under the harsh treatment process, which would likely result in a scrapped part.

How it Works

The basic geometry of all the parts is cylindrical, but the team realized that their machine would have to accommodate a wide variety of part diameters and lengths. The machine uses a set of adjustable rollers to spin the part during the taping operation. Two non-driven rollers are mounted to a endplate assembly which can extend on a linear bearing to accommodate different part lengths. A single active roller is driven by an AutomationDirect SureStep® stepping system. A second SureStep stepper axis is used to position and traverse the tape dispenser. Arduino, an open-source prototyping platform, is used to generate the pulse and direction signals required to operate the SureStep systems. A second microprocessor in the form of a Raspberry

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Pi (a highly-integrated, single board computer) is used to display a graphical operator interface (GUI) to the operator. This GUI accepts operator input for part length, part diameter, desired part RPM, start of tape sections, end of tape sections, tape overlap percentage, tape width, tape type, and the number of taped layers. Once the operator inputs these parameters, the GUI converts those inputs into industry-standard G-codes (variables) that are executed by the Arduino. These G-codes can also be saved to disk (on the RasPi) as a text file. This allows the user to program one operation per part, and run/save it multiple times, a vital capability for cost-effective operation with low cycle times.

The machine also incorporates a set of Contrinex light curtains and a stack light from AutomationDirect to ensure machine safety, and to enhance communication with the operator. A pair of Hubbell/Wiegmann enclosures (with Stego cooling fans), and an IDEM emergency stop control station (also from AutomationDirect) complete the control system.

Machine Operation

After the user enters a part program and clicks "Go", the Arduino calculates the exact number of steps required for the tape translation motor to move the tape roll to the center position of the section to be taped. All motion stops, the light curtain is temporarily disabled, and the operator is instructed to apply the tape from the roll to the part.

"We chose to have the user apply the tape at the center of the taped section to minimize error. If we ask the operator to apply the tape to the starting edge of a section there is no way the machine could hold the tolerances that we were hoping for." explains Sobanski.

Once the operator's hands are clear, the machine then takes over and begins to tape the part. The machine takes part diameter, section width, and tape width all into account. "To put it simply, the part must rotate more if the tape is thinner, or if there is more tape overlap. The roller distance and tape translation distance are then linearly interpolated in the Arduino so that they reach their respective final locations at the same time." continues Sobanski.

Once a section of taping is complete, all motion stops for a second time, and the operator interface prompts the operator to cut the tape off the part. That completes one automated taping operation. If the part has additional sections to be taped, the sequence is repeated.

Safety

There are multiple safety features incorporated in the design. On power up, the machine requires a homing cycle to determine where all the moving parts are located. Other safety measures include limitations on part RPMs and feed rates. PAS Technologies requested a maximum of 120 RPM; therefore regardless of user inputs, the machine enforces that speed limit. Furthermore, feed rates on the part translation are kept to safe levels. The machine also monitors the light curtains and will "pause" operation if they are tripped. Once the obstruction is removed, the machine will resume normal operation. As a further precaution, soft endstops are programmed into the Arduino, which prevent over-travel and crashing of the tape translation system.

Accuracy and Tolerance

After the final machine was assembled, the team ran multiple tests to see how the actual tolerances compared to the tolerances requested by PAS Technologies. For any desired taped section, the machine is currently accurate in covering 99.9% of the required area. For example, on a 1-inch tape section, the machine is off by only ten thousandths of an inch. However, with longer tape sections, the tolerance increases. To combat this issue on larger tape sections, the team plans to incorporate a scaling function to the calculation that should compensate for the length.

continued >>

Cycle Times Reduced by 75% or More

As stated previously, one of the main goals for this project was to increase operator efficiency by reducing the cycle time required to tape a part. Hand taping operations can vary from five to 25 minutes, depending on the part geometry. The team defined one 'cycle' to include: uploading full part dimensions into the graphical user interface, taping the section, and cutting the tape once the part is complete. After multiple tests, automated cycle times were determined to be approximately 90 seconds per tape section. However, this figure includes the time taken to program the part parameters (typically over half of the total time). If multiple parts exist with identical sections to be taped, the average cycle time decreases even further.

Donald Scott, Engineering Manager with PAS Technologies, worked with the team throughout the design and build process. He was very impressed with the results. "The team has achieved all the goals we set for this project. We have a safe, easy-to-use machine, which drastically reduces the time required to tape the parts. And best of all, because the team has documented the machine so thoroughly, it will be easy for us to replicate the machine for added capacity in other areas of the shop."

Demo Day

The University of Connecticut's School of Engineering holds an annual Demo Day to celebrate and evaluate all the capstone projects from the various undergraduate and graduate teams. Held on April 29, 2016, at Gampel Pavilion on the Storrs campus, well over 100 teams from across nine engineering disciplines displayed and demonstrated their projects. Out of 49 mechanical engineering projects, Team 22 was awarded a first place ranking. Sobanski was elated "We were thrilled to be recognized at the Demo Day event. It meant a lot to us to be selected from among all the amazing capstone projects that were on display."

Photoelectric Sensor Terms

T R U B M B R E A K S T A I N L E S S S T E E L C
N O R M A L L Y C L O S E D L I K O Q Y P F C Y I
E T S R H C O R R E C T I O N F A C T O R S N R R
M C R L B N K M A E B S U O N I M U L C Y E A P T
E E U Q R O T G N I N E T H G I T A E S T Q T B C
L L M P E I N F R A R E D Y N N R T E S I T S Z E
E L O U F T A X S O C L A O O I A A V N V Y I Z L
G O B F L C Z H J U U M R I Z R A R I O I S D Y E
N C A G E E U K Q S P N T E E H E G T I T C G S O
I N D U C T I V E L O A D P R O T E C T I O N T T
H E F C T O A T I B U R O S N E S T E C S D I E O
C P D E O R U F P N E K I P U A N G L E N S T K H
T O R L R P I B E F R J Q C Z P D Z F N E R A C P
I S I V T E C T L A I X A X O M P I E N S E R A E
W N S U R G T E D D R E C E I V E R R O I T E R C
S N O I T A C I D N I T H G I L S S E C X E P B N
C F S T A T U S I N D I C A T O R S S S F M O G A
L K I U I L I G H T O P E R A T E V U I S O B N T
E D P V C O M P L E M E N T A R Y J F D L I Z I P
A X E S P V T H R O U G H B E A M G F K E T O T E
R T T H E R M A L E N D U R A N C E I C A N R N C
A P R O T E C T I O N D E G R E E J D I K E A U C
N L Q C N V O P T I C A L F I B E R S U A T T O A
C V E K L O A D R E S I S T A N C E D Q G O M M K
E N O I T C N U F H C A E T R E T T I M E P G U F

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