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How Present-Day Automation Trends are Driving Next Generation Machinery

By Jeremy Miller

The landscape of the modern machine builder

With the advent of industry buzzwords like “Collaborative Robotics” and “Industry 4.0,” machine builders of today are feeling increased pressure to provide a new level of intelligent and flexible automation. A revolution taking place in the industrial marketplace is the Industrial Internet of Things, which describes an industrial network of devices embedded with electronics, software, and sensors, capable of collecting and exchanging data to more effectively and efficiently drive machine behavior. Trends like this are pushing an evolving industry to the forefront of technological advancement.

This move has manufacturers migrating towards increased data collection and resultant decision making to maximize factory throughput and efficiency and reduce downtime on the floor. These pressures to continually advance technology do not go without their own challenges, and the machine builders supplying this automated equipment are forced to constantly re-invent in order to remain sustainable in the market place.

Modern day designers and manufacturers of automated machinery are faced with increasingly demanding customer and application requirements. Increased throughput and machine uptime are major initiatives, creating demand for high speed, highly flexible and highly reliable componentry. Equipment designers that can provide on the fly, rapid change-over of product or process are becoming more the norm than the outlier. In addition, the competitive environment continues to expand its global reach creating true buying power for the consumer and forcing tight cost constraints and ultimately imposing a “do more with less” mentality for the machine builder. Component cost, complexity, and general ease of use are of even more paramount importance than ever before.

This whitepaper covers some of these challenges and helps outline how machine builders are creatively addressing them today.

Industry Overview: A Shift to Flexibility

Hard Automation

Industrial automation is undergoing a shift from a conventional, fixed equipment design to that of highly flexible machinery. This shift is driven in part by a demand for low volume, high mix style production and a shorter product life cycle, which is better suited to support an increasingly dynamic marketplace. The more traditional fixed equipment approach was designed to serve one, and only one purpose, as manufacturing floors of years past traditionally produced only a limited assortment of products at large volumes and with limited variability.

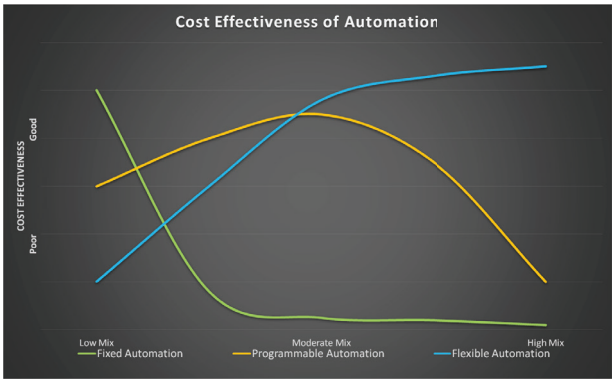
This “Hard Automation” employs a machine design approach consisting of very fixed sequences within a machine cell utilizing fixed mechanical constraints, and designed for processing or assembly of a single product. Modularity was not a consideration within the design intent and therefore converting machinery of this type to support other products or processes requires significant mechanical design changes along with programming. These conversions are often financially impractical or unreasonably challenging to implement, and therefore, in many cases as new products are released, this equipment is scrapped and completely new equipment is acquired.

Increasing Flexibility

As design strategies have evolved, changes in design intent have led to machines integrating improved flexibility relative to fixed equipment. Manual changeover equipment that can accommodate some level of configurability after implementation has become more commonplace in machine design. This includes the ability to write new code for performing new operations in combination with manual changeovers of the mechanical system to produce new products. This changeover process, while adding a level of flexibility, is often very labor intensive and requires significant machine downtime, which makes it ideal for batch style manufacturing but not necessarily high mix product lines.

Soft Automation

The third and more modern approach to automated equipment is fully flexible automation, often referred to as “Soft Automation.” With this methodology, a combination of recipe control and flexible mechanical automation allows the machine operator to seamlessly convert from one process or product to another at the touch of a button. This means that not only can manufacturers produce a greater variety of products with a single machine, but they can also address a future state incorporating next generation products. This flexible automation is accomplished through utilization of the latest in automation technology.



The above graph represents the three automation philosophies discussed. This demonstrates that as variability is introduced more flexible solutions improve cost effectiveness.

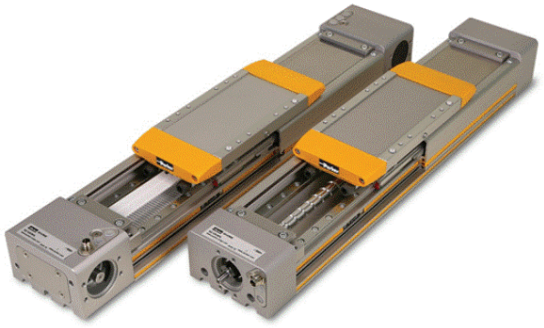
Most manufacturing today still uses more fixed or manual change-over equipment than truly flexible automation. This makes it much more difficult not only to adapt to a low volume, high mix demand, but also to adopt an ever evolving product portfolio.

Machine Builder Challenges

Complexity & Scale

Perhaps one of the greatest challenges facing machine builders today is that of design variation. Historically, automated equipment providers could go to market with a standard platform product designed to fit a set core of products or processes. By employing uniform design platforms from machine to machine, designers are able to standardize on mechanical and electrical components.

To provide truly flexible automation, motion componentry must be able to not only achieve a multitude of varying positions to accommodate machine change-over, but additionally to cover a broad range of application demands. As performance criteria change from one machine to the next, machine designers are faced with the complexity of selecting from a multitude of automation components to accomplish this application variance. This can dramatically increase design and integration complexity. To solve this challenge, machine designers have found relief in integrating highly configurable componentry into their designs.



Parker’s HMR is a high moment rodless actuator, featuring dual square rail guidance and belt or screw drive train. The HMR is offered in five different frame sizes to cover a range of loading requirements and heavy or light extrusion profiles for supported or unsupported applications.

Increased Throughput & Reduced Downtime

High speed and highly efficient changeover is an absolute must for modern flexible machinery. Conversion from one machine process to another often incorporates multiple automated functions acting in unison. The components designed for this function must support high speed operation with fast response time to react to dynamic positioning requirements.

Along with an ability to quickly adapt to demand variability, today’s modern flexible machines must maintain extremely high levels of reliability. As unanticipated downtime on the line is intolerable, preventative maintenance if required must be extremely simple, quick to perform,

and required infrequently. Only when reliability, reduced maintenance complexity, and accelerated changeover rates are combined during the design process can the machine truly achieve maximized uptime.

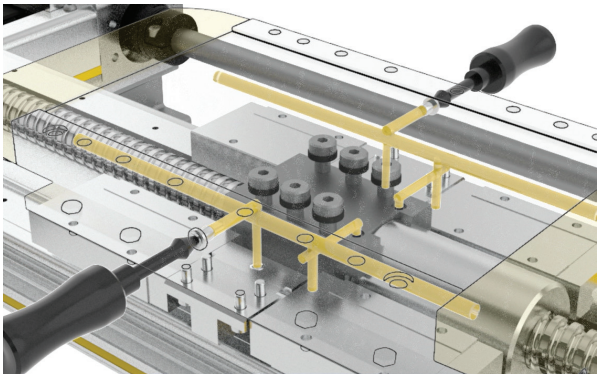


Image from HMR demonstrating single point contact to lubricate all bearing trucks and ballnut simultaneously.

Global Support

Across a multitude of industry sectors one thing has become increasingly clear: the need for global support at both the machine and the component level is paramount. For machine builders this means not only providing localized support but also an ability to support a customer base stretching the reaches of the globe.

Technology has helped advance this effort. With a focus on the Internet of Things, products like HMI's (Human Machine Interfaces) can capture real-time data on the plant floor and publish it out to the web for viewers to use to make informed decisions. This means that a support team from the machine builder can access diagnostic information from their customer's plant oceans away and implement resolutions immediately.

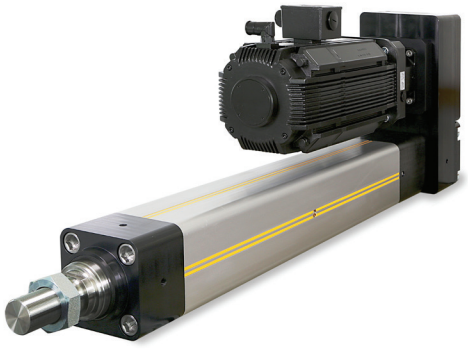
In addition to full machine support, partnering with component suppliers that can provide global manufacturing allows for not only support within the country at hand but also designing and manufacturing products that offer feature sets demanded by regional preferences.

Energy Efficiency

With an ever increasing push towards energy efficiency coming from overall plant-level cost reduction efforts in addition to federal regulation, a reliance on traditional fluid power means industrial automation is swiftly migrating to higher efficiency electric solutions. Plant managers are realizing that while the upfront capital investment for fully electric machinery can be significantly higher, the overall cost of ownership is greatly reduced. Additionally this machinery is cleaner (without the concern of fluid leaks), quieter, and provides a more compact solution, thus taking up less highly valued floor space.

The secondary effect of adopting servo controlled electric motion is that the equipment operates with significantly increased accuracy and functionality. This accuracy can range from more accurate dispensing to greater force control, which all equates to higher quality products and lower scrap rates.

Electric cylinders provide an excellent example of products ideally suited for fluid power to electromechanical migration. Many rod style or electric cylinders today are manufactured to industry-standard mounting patterns, making them easier to integrate into existing designs. Additionally, through the use of force sensors, these cylinders can provide closed-loop force control, giving substantially better regulation of force output and an ability to quickly respond to changes and adapt the output force accordingly. This enhanced performance relative to traditional fluid power can equate to improved quality at the production line, as well as overall cost savings.



Parker's ETH cylinder features ISO standard mounting and thrust forces up to 25,000lbs, making it ideal for fluid power conversion.

Configurable and Scalable Automation Solutions

With the number of challenges facing modern day machine builders, how can manufacturers of automated equipment alleviate some of these challenges? At least part of the answer to that question lies in designing scalable and highly configurable product platforms that can address a broader range of application demands.

One example of such products includes mechanical stages that feature multiple drive trains, guidance, frame sizes, and other scalable options that allow for flexibility and easier integration into tight space constraints. Components like this can greatly simplify the design process and allow designers to standardize single product families that can solve a significant application variation, reducing design time and speeding the path to market.

Parker's OSPE family of products shown here offers over 55 different configurable options, between frame size, drive train and guidance options.

Trends within the industry and the associated challenges that these create for machine builders have become universal throughout many of the various markets that machine builders serve. Here are some specific examples that highlight the challenges and potential solutions being implemented.

Packaging Industry

The packaging industry provides a prime example of an industry with a severe appetite for greater levels of intelligent and flexible machinery. Product marketers are constantly pushing to evolve and adapt product containers in an attempt to draw the consumer eye and address changing buyer preferences. Trends like single serve packaging, use of more sustainable, eco-friendly packaging, and integration of high quality, visually appealing imagery are just a couple of maneuvers that packaging manufacturers use to help differentiate themselves.

As speed to market is an absolute must for success of these consumer packaged goods (CPG), saying that the pace at which packaging evolves is rapid is an understatement. To keep up with these changes requires that packaging lines must undergo lengthy and costly upgrades with a high level of frequency to address rapidly changing package designs. This not only requires significant capital investment but also incurs risk, as it does not necessarily align with the initial design intent of the equipment. Alternatively, by utilizing flexible machinery, CPG producers can change parameters on the fly to compensate for different container form factors, thus reducing Total Cost of Ownership (TCO) and mitigating potential long term risk.

To manufacture this level of modular and adaptable machinery requires a level of consideration for product variation, material variation, and even machine operators during the design of the machine. This is a shift from a more traditional design process where only the current product is considered during the design. While this does create a more complex and dynamic design process, it ultimately has proven to provide significant value to the customer.

Machine builders are finding success in their ability to promote this additional value to their customers, and provide a vision for greater overall cost of ownership, reduced long term risk and greatly improved overall equipment effectiveness (OEE). To this extent manufacturers have altered their purchasing criteria to start including productivity and flexibility specifications in initial decision making criteria.

The ability to offer increased speed and throughput, reduce downtime during changeovers, and to maximize overall machine uptime has become a differentiator for packaging automation providers, and it will ultimately dictate the success of the machinery.

This shift from a more traditional “one size fits all” approach to a focus on equipment that is adapted specifically to ever-changing product form factors can provide significant challenges to machine designers. One way to mitigate this challenge is to find the right automation component partners to provide flexible, scalable products that easily adapt to constantly changing machine designs.

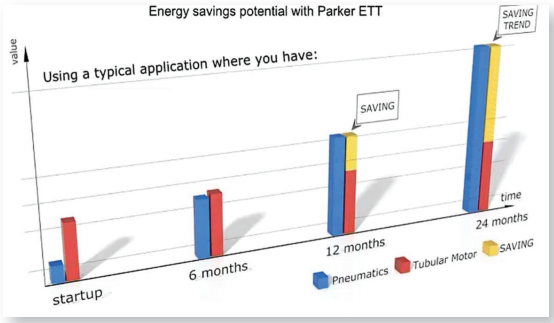
Products like Programmable Automation Controllers have been game-changers by providing a single architecture for motion and machine control that streamlines both set-up and re-configuration due to product lines changes in the future. This allows for a single development environment as well more tightly integrated hardware and software, thereby improving overall system cost and complexity and allowing for greater versatility.

Parker’s Automation Controller or PAC can perform full machine control and high speed motion control utilizing an EtherCAT motion bus. In addition the PAC incorporates a full visualization package.

Additionally some PAC controllers provide a Remote Management features that allows users of packaging equipment to access key metrics from anywhere in or outside of plant walls, making real-time response a reality. SCADA (supervisory control and data acquisition) level software packages often integrated into HMI platforms have allowed this industry to not only track critical data from the machine or complete line of machines, but also to compare relative data points to perform trending analysis, providing owners the ability to make empowered and informed decisions to maximize machine performance.

Mechanical solutions that incorporate greater configurability and flexibility are also critical to this mix. Highly scalable solutions can simplify design efforts and reduce overall design time from machine to machine. Pairing with the right automation partners that can provide all of these features from a single source can add significant value to the design by simplifying system integration and providing a single source for support.

Manufacturers of consumer packaged goods are not only pushing for this enhanced level of flexibility, but additionally require a focus on total cost of ownership (TCO). Having more of a TCO mindset during machine design requires increased effort to source highly energy efficient products. This strategy his accelerated a migration from traditional fluid power technology to electromechanical solutions. Inherent to their design, electromechanical positioners have very high mechanical efficiency relative to other actuation technologies. While the upfront cost is typically higher, this efficiency has proven to deliver greatly reduced energy utilization, dramatically improving the return on initial investment.



Tubular linear motor technologies like the Parker ETT have been proven to dramatically reduce ROI given the significant improvement in energy efficiency.

Automotive Industry

Many machine builders supporting the automotive industry must design highly customized equipment to support a diverse range of potential product and process demands. Performance and application requirements can vary from one machine to the next, or even from one side of the machine to the other. These variances can include stroke length, payload, thrust, speed, and precision. Traditionally each unique requirement would need a different mechanical product solution, creating significant design and integration complexity.

To best address the complexity created through varying application demands, these equipment manufacturers are looking to component suppliers that can provide scalability. This means addressing a significantly greater range of application requirements from a single go-to product.

One such example of this strategy is a custom machine designed to fabricate an engine block component. This component requires multiple different operations to flow from raw material to finished good. Each of these operations require different tooling and applied forces for forming and assembly and in some cases multiple axes of motion within the same process step.

In this case Parker's HMR actuator provided the ideal solution. As the actuator series is offered in five different frame sizes, it was able to support the large variety of different payload capacities required. Additionally the stage is offered in either belt or ball screw drive train, solving the challenge of high thrust requirements and high speed on the same machine. Finally, there are a number of standard configurable options offered on the HMR, including multi-axis mounting. All of this provides the level of scalability needed, simplifying the overall design process.

Robotics

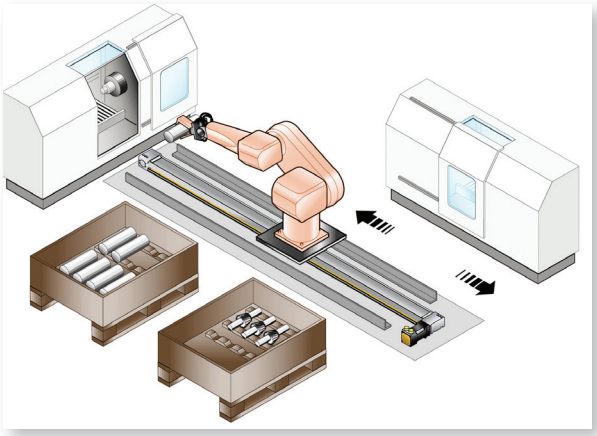
Robotic automation has been in existence for a number of years, but has really taken center stage over the past several years, in large part due to an influx of more cost competitive, highly flexible, and extremely user friendly interfaces. Robots have evolved to utilize a more compact footprint as well as integrating simpler designs, thereby reducing cost and potential maintenance. In addition the onset of collaborative robotics has driven the robotic space to the cutting edge of automation technology.

Until recently man and machine were distinctly segregated in the manufacturing space. More traditional/non-collaborative robotic solutions move at speeds and forces that demand the use of safety enclosures. Due to this constraint, these robots are often fixed elements on the plant floor, designed and utilized for one operation and one operation only. The advent of aptly named "Collaborative Robotics" has allowed for the introduction of human labor in the robotic workspace, allowing these robots to operate in a virtually cage-free environment. This not only increases the flexibility of the robot by allowing it to be re-positioned to accommodate a dynamic manufacturing environment, but additionally increases overall efficiency and throughput by integrating the manual and automated workforce.

These robots have found homes in machine loading and unloading, mechanical assembly (such as welding, riveting, etc.), and many others example applications. While robots can increase overall system efficiency and throughput, they are still somewhat limited. Articulated robotic arms have a limited potential addressable footprint. This means that some operations require either multiple robots with parts mechanically or manually transferred between them.

What has become even more popular among integrators and machine builders today is the use of Robot Transfer Units (RTU). In this case the robot arm is mounted to fixed linear stage and transferred back and forth between operating stations. This reduces the overall capital impact of having two robots and transferring product between them, and additionally it increases overall throughput.

One such example of this is shown below. In this example an articulated robot is mounted to Parker's HMR actuator. The HMR is designed to handle the large dynamic moment loading of the robot arm in motion. In this application the HMR is transferring the robot arm from one CNC machine operation to another to allow the robot to load and unload parts at varying stages of operation. In this case, along with increased throughput, the added benefit is that the CNC machines are able to maximize machine efficiency by maintaining a set-up to run a single part instead of continuously changing fixturing to adapt to the multiple operations of a single part.



In this case, Machine 1 performs the first operation, then the robot removes the part, the HMR transfers the robot to the second machine to load the part, a completed parts is then removed from Machine 2, the robot is transferred to material storage, and the part is placed in the completed part bin. Then a new blank part is taken, the robot is transferred back to machine 1 and loaded. The cycle continues form here.

A stand alone articulated robot would not be able to perform all of these tasks due to available stroke, however by integrating a single linear stage allows for much greater reach and functionality.

A Paradigm Shift for Machine Builders

The machine design landscape today is dramatically changing due to pressures to design more dynamic machinery with increased functionality and flexibility, all while reducing the design cycle. However, solutions exist to help make this possible without eroding margins and adding significant organization resource drain.

Utilizing the latest in design tools and CAD software can provide significant speed to design of new and unique equipment. Incorporating smart technology like automation controllers that can manage machine and motion control in an integrated platform offers flexibility. Visualization products can provide recipe control for the operator, collect data to track throughput and machine efficiency, and optimize workload. Integrating the right pairing of mechanical solutions that are innately scalable and configurable can reduce design time and complexity.

Ultimately, with a little research and the right tools, the machine builder can design truly flexible automation systems for today's challenging marketplace.

About the Author:

Jeremy Miller is a product manager for Parker's Automation Group focusing on linear mechanical stages. Jeremy has over fifteen years experience in the Automation Industry. ravis has an extensive background in motion and control and has worked hand-in-hand with many designers implementing eletromechanical systems.

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