KINEMETRIX
AGILE AUTOMATION

165 TRADE ST. LEXINGTON, KY 40511 P 859.381.9937 F 859.381.0937

A reference to accompany the presentation:

"Get Flexible: How to Profit from Agile Automation"

ASSEMBLY TECHNOLOGY EXPO

September 22, 2009

Presented by: Jim Peyton
President
Kinemetrix

Contents

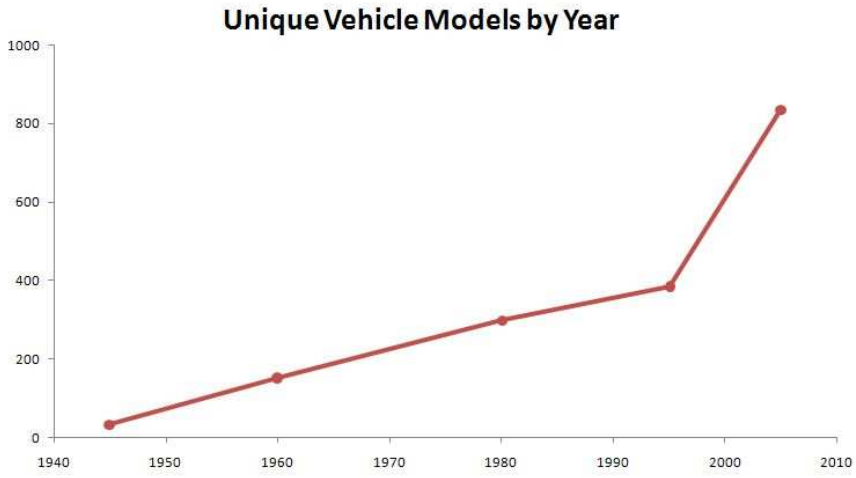
THE ORIGIN OF AGILE AUTOMATION

We live in a time when global economic forces are fast and turbulent. It's been quipped by military strategists that, "No plan survives first contact with the enemy." The wisdom of this observation parallels the realities faced by most manufacturers today.

Industry Trends

Product incubation cycles continue to be compressed, as producers scramble to be first to market with an innovation. Production lifecycles are foreshortened, as the pace of technology renders designs obsolete by the time they hit the marketplace.

Products are being offered in a greater number of variations to capture a larger market and capitalize on the consumer's new-found expectation that products be more personalized.



Example of increasing model mix in automotive industry

In addition to the demand to move quickly, let's not forget, the going rate for an hour of assembly work is $0.60 in low wage countries.[1] And the customer expects zero-defect quality levels.

So now we find ourselves kicking off production while the product is barely through design, with minimal market research to guide production volumes. We have to get into the market fast, make a profit, and then quickly move on to the next product.

The trend toward shorter product development cycles is more likely to continue than reverse. Production volumes appear to be shrinking at an accelerated rate as niche markets are exploited. The logical termination of this trend is mass-customization, a production batch of one piece. For a few specialty products this limit has already been reached.

Recent events suggest that those who can't adapt to the new realities ahead will be overtaken by those who can.

Curveballs and Flaming Chickens

It's a fast-changing world. Customers are going to throw you curve balls. Sometimes they will throw you spastic flaming chickens. How well is your company prepared to handle the following?

- You have the opportunity to win a piece of business if you can PPAP in 8 weeks
- The product design changes significantly after start-of-production
- Volume drops to 40% of contract output
- A competitor emerges from thin air priced 25% lower than you
- Volume requirements on a contract double, but only if you can grow capacity in 3 months
- A competitor just became a customer
- A customer just became a competitor

Any attempt to create long term production forecasts based on a snapshot of the landscape today leads to fragile conclusions at best. A better strategy might also be borrowed from military planning: Be prepared.

ROI Calculations Can't Keep Up

Even the standard return-on-investment (ROI) calculations have become obselete for guiding manufacturing equipment investment decisions. **The time between start of production and product obsolescence is becoming shorter than the useful life of a typical automation system.**

Now What?

We've explored two facts that are sharply at odds with one another.

1. You have to automate to achieve the quality and cost structure required to remain competitive.
2. You can't justify automation investment because short production life or low volumes defy standard return-on-investment analysis.

What if you could simultaneously:

- Solve these conflicting constraints
- Insure your investment against the effects of rapid change
- Pull your customers closer
- Win new business

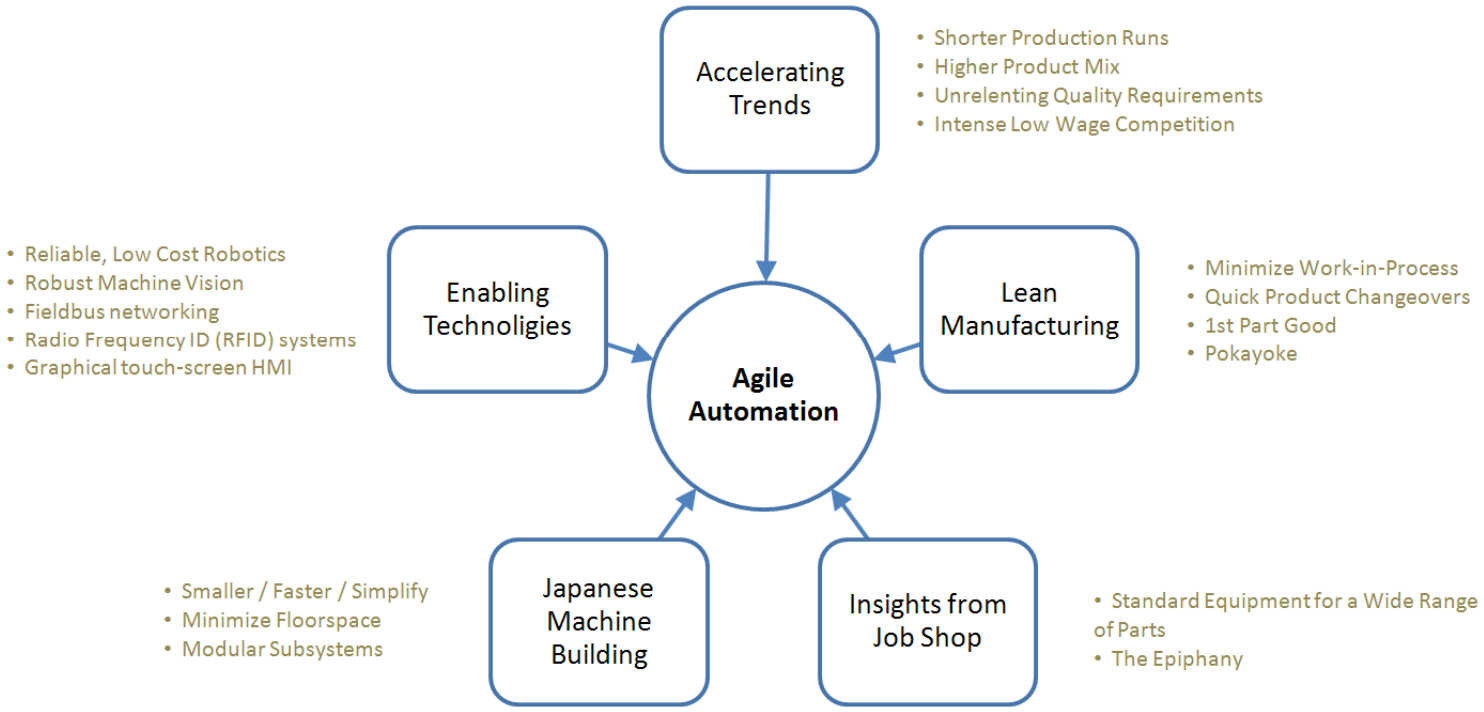
Since our first Agile automation system, we've implemented numerous projects for our customers that have achieved these objectives.

Every challenge presents an opportunity. If you can recognize and accommodate these new realities better and faster than your competition, you gain the advantage. Going forward, successful manufacturers will be the ones who automate aggressivelywith agile equipment.

A Different Way of Thinking

Agile automation is a different way of thinking about automated equipment. It refactors conventional wisdom to put focus on the variables that are more relevant in today's manufacturing arena.

The need to produce high quality product, efficiently, while preserving the ability to adapt quickly required us to focus on change activities. These changes range from frequent product changeover, to a new product launch, to a major plant reconfiguration. Scrutinizing how well the system design deals with change at all of these levels will most accurately evaluate the system's value for a manufacturing plant in our changing world. Agile automation was forged as an extension of Lean manufacturing principles, Japanese machine building techniques, and key insights from our own manufacturing operations.



Over a decade ago, in thinking through the challenges of designing automated machinery for multiple products, including those products not yet conceived, there was an epiphany. On our own manufacturing floor stood modern CNC machines that were highly automated, yet so generic in capability as to be able to perform a wide variety of processes on an unimaginably diverse range of parts. So why did factory automation have to be any different?

What resulted from that line of questioning is the insight that a CNC machine owes its flexibility to standard, crisply-defined interface points between the process and part-specific tooling. In the case of the CNC machine, that interface is simply the machine table and the toolholder. Everything part specific can be easily removed from the machine to make way for the next setup.

At the core of designing Agile equipment is the concept of decoupling part-specific tooling from process-specific machinery.

In traditional automation, it is common to have part specific hardware, sensors, air lines, and software code hopelessly intermingled with core machine elements. Interestingly, this tangling of functions resulted not from fundamental barriers. In large part, it occurs because nobody gave it much thought. A machine was specified for a particular part, or parts and the engineer took the shortest path. **The result is a machine that is almost completely useless outside its narrowly defined purpose**.

The essence of machine agility is the concept of decoupling part-specific tooling from process-specific machinery. For some parts and processes, like an assembly press, this is easy. For others, maintaining a crisp press/die relationship between machine and part-specific tooling can stretch the creativity of even the most talented of engineers. Kinemetrix has developed a collection of design guidelines and Agile techniques to accomplish this decoupling process. We share some of these in this guide.

AGILE BENEFITS

Properly implemented, agile equipment returns benefits well beyond the shop floor. We group these benefits into operational and strategic categories. **Operational benefits** include those that improve day to day efficiencies. **Strategic benefits** offer the durable competitive advantage of agility at the organizational level.

Strategic Benefits	Operational Benefits
• Hedge Risks • Delayed Obsolescence • Streamline Product Launches • Tighten Customer Relationships • Win new business • Reduced Cost for New Jobs	• Reduced Changeover Time • Reduced WIP • Reduced Floorspace • Consistent Quality • Flexible Capacity Management • Easy Continuous Improvement • Commonized Spare Parts • Reduced Training Time

Operational Benefits:

Machine Agility is particularly valuable to practitioners of Lean Manufacturing. Those manufacturers on their lean journey will recognize the importance of many of these operational capabilities.

Reduced Product Changeover Time

By radically reducing or eliminating part-specific tooling, product changeover times are driven as close to zero as possible. This provides the primary benefits of reducing direct labor and machine downtime.

Less Work-In-Process

More efficient product changeover allows more frequent product changeover without impacting overall throughput. Frequent product changeover allows you to produce in accordance with customer demand, rather than creating large batches. Reducing Work-In-Process (WIP) frees cash that would otherwise be tied up in inventory. This cashflow increase can be put to use more productively in your business.

Reduced Floorspace

One agile system can run a variety of parts that would require many hard automated machines with their associated floorspace. Keeping old machines around to run service parts and short-runs is not necessary with Agile automation. At the end of a product's production cycle, simply store any part specific tooling (if applicable) rather than entire dedicated machines.

Faster changeovers also reduce WIP. Less WIP requires less floorspace for incoming product and finished goods.

Consistent Quality on Changeover

Stability is the goal of every manufacturing process. The first part of the shift or after changeover should be a sellable part with no rework required. By minimizing or eliminating human intervention during changeover, Agile systems ensure consistent quality on startup and after product changeover.

> Think of any cost premium associated with agile features as inexpensive investment insurance.

Flexible Capacity

When multiple Agile automation systems are deployed for similar processes, the tooling is fully interchangeable across machines. When fully tooled, it's possible to run machines in parallel on the same product. This offers tremendous flexibility to respond to wide swings in demand. This comes at a fraction of the cost of multiple dedicated machines.

Agile Designs Support Continuous Improvement

Standardization is the bedrock of kaizen. Standardized machines with interchangeable tooling, standard user interface, and common spare parts, make continuous improvement easy on an Agile system.

New tooling ideas can be switched in and out quickly without risking production tools or process settings. Trials and improvements can be conducted during breaks rather than waiting until weekends and holidays. Process settings from kaizen activities are automatically recorded in a recipe management system so that lessons learned aren't lessons lost.

Reduced Training Time / Common Spare Parts

The result of the effort to definitively separate part-specific tooling from the machine function is that otherwise *similar* systems become *identical* systems. This standardization means that when your operators and technical team are trained on one machine, they're trained on all machines.

The same effect translates to spare parts commonality. This reduces the hidden cost of maintaining a larger than necessary inventory of spare parts for machines.

Strategic Benefits

Manage Your Risks

There are no shortage of risks inherent to an investment in automated equipment:

- Risk of dramatic product design change
- Risk of program cancellation or volume decrease
- Risk of undercapacity or poor capacity balance
- Risk of missing a production launch date
- Risk of having to spend late nights at the plant instead of your kid's school play.
- Risk of project failure

Agile automation gives you the ability to manage these risks. Think of any cost premium associated with agile features as inexpensive insurance. Of course, in most cases when benefits are fully recognized, there is no cost premium. So you get the benefit of broad investment security for free.

Agile automation enables <u>you</u> to compete with <u>this</u>

Delayed Obsolescence

At the end of a product's lifecycle, Agile automation's modular design lends itself more readily to retooling or reconfiguration for new production demands. Whether the end of production comes according to plan or otherwise, Agile systems have value that is not lost, hopelessly entangled in a part-specific design.

Reduced Product Launch Costs

The current pace of product turnover exposes costs that were not considered in the days of million-part runs. Product launches represent a larger and larger percentage of product lifecycle costs as production volumes shrink.

In general, a launch on Agile equipment involves simple tooling and program changes. Best practices and production parameters from other products can be used as starting points. The result is:

- Minimal cost and lead time for fixed tooling purchase.
- Reduced process equipment debug time and development risk
- Simplified ISO / PPAP documentation by recycling content from previous programs

Reduced Cost for New Jobs

Agile automation allows you to prepare for new jobs with a small tooling investment as opposed to entirely new machinery. This lets you quickly meet startup capacity requirements on existing agile automation, adding new machinery only as throughput requires. Agile automation lends both a tooling cost savings and a capital investment savings for new business.

Tighten Customer Relationships

Turn your customers into raving fans by responding easily and quickly to product changes, prototype requests, and emergency orders. This responsiveness gives you a distinctive edge.

Agile automation helps to cement existing customer relationships in other ways:

- It offers product design flexibility that will delight your customer.
- The process of designing an agile system involves predicting likely variations in future production. You will have a reason to discuss future product pipeline with your customer. This process deepens your involvement with your customer.
- You need only to build prototype tooling to allow actual production equipment to be used for Product R&D under shop floor conditions. This capability eliminates surprises during product launch.

Win New Business

What story do you have to tell prospective customers? What differentiate your manufacturing capabilities from your competitors? When you can walk your prospective customers through your plant and demonstrate your manufacturing agility, they will take notice.

With Agile automation, your cost structure allows you to profitably produce the lower volume products that your less enlightened competitors can't touch. And because your tooling costs are minimal, simple, and well understood, you can respond quickly to customer pricing requests and compressed product launch schedules.

When your competitors are not agile, they can't respond in this way. Your company is the one that wins the new business.

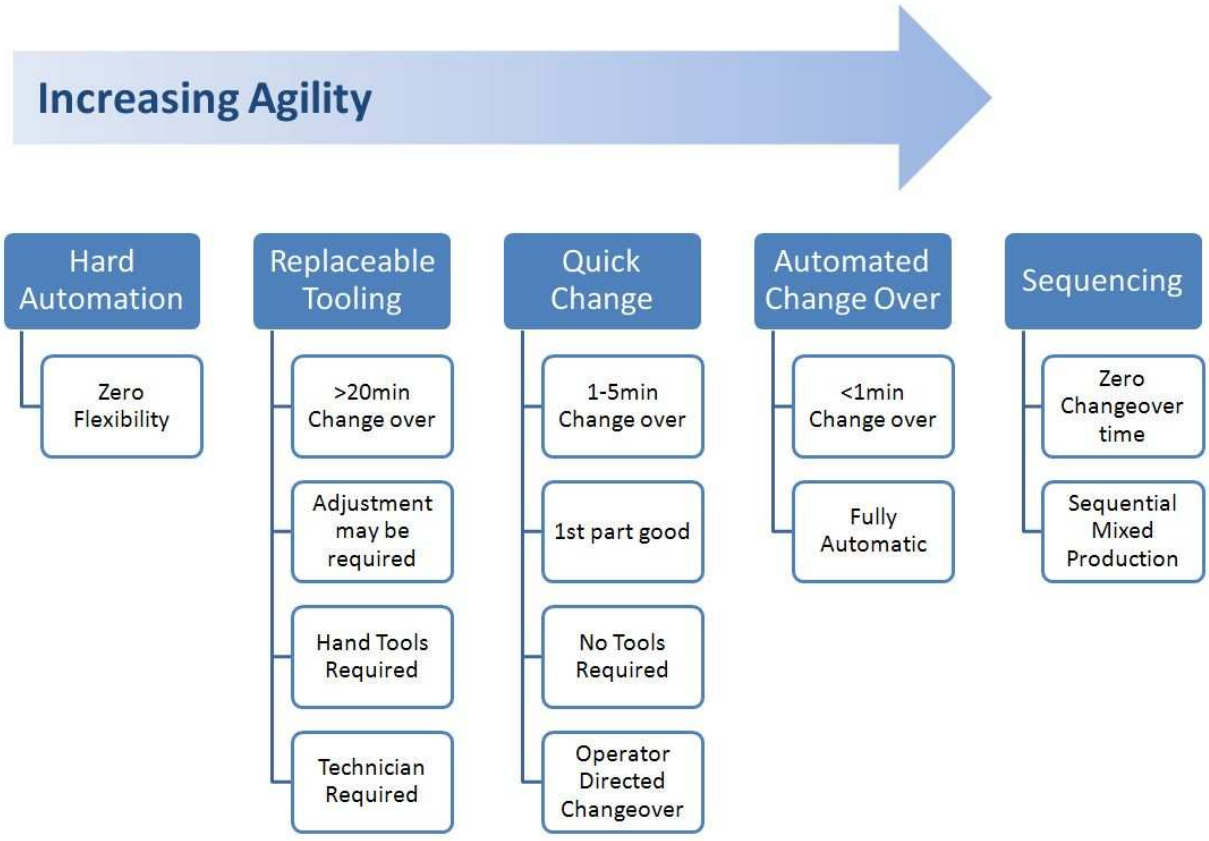
DEFINING AGILE

Agile automation equipment handles two important tasks:

- Efficiently produces the products in your plan
- Adapts quickly when that plan changes

Specific Measurements of Operational Agility

The benefits of Agile automation reach across many areas of your organization, extending into your suppliers and customers. To facilitate all stakeholders reaching a common understanding, Kinemetrix has developed useful definitions for discrete levels of agility.



Each step along the Agile automation continuum aligns with a level of operational and strategic benefits. The best value is had when the intended level of agility is clearly identified early in the process. Features that add cost to a system without fully reaching the next level of agile benefits dilute the value of the investment.

Before we move on, let's clarify what Agile automation is **not.** Agile is not simply putting a robot or vision system into a workcell. These tools are almost universally more flexible than hard automation. But a robot alone does not necessarily move you to the next step on the continum.

AGILE AUTOMATION TECHNIQUES

Getting Started

You wouldn't buy a six-figure stamping press and stick-weld a die in place. So why would you buy an expensive piece of automation that is dedicated to a fixed number of products?

That's the perspective to take when developing agile solutions. The big ideas at work while concepting an agile system are:

Decoupling

- Creating a crisp division between the product specific tooling and the machine.
- Defining logical sub-system breaks in the machine to reduce cost of reconfiguring or re-deploying assets. This concept extends from mechanical design to electrical and software design.

Commonization

- Collect all common features of existing production parts. Work with product designer team to establish hard-points in the product design that will not change across different models.
- Instead of looking at an overwhelming pile of differences between products, learn to shift your focus to the similarities. With practice, the results can be surprising.

Variation Analysis

- Explore with the product design team what parameters are likely to vary, and by how much.

At first, asking for specifications on parts that have not been conceived of will get you terse, half-annoyed responses. If you persist, you'll find that most products have some boundary conditions, however broad they might seem at first.

The other side of the equation is to explore, with your machine builder, the likely costs of each point of variation. You may find that providing a safe amount of variability on a given parameter may not add to cost at all. The trick is to understand what variations are likely, the reasonable magnitude of the variations, and where the significant cost thresholds for accommodating these variations reside.

The Conceptual Design Process

Agile automation design, like chess, is guided by a few simple rules that are easy to learn, yet require practice to master. Here are a few of the more important guiding principles:

- Aggressively minimize hard tooling. Hard tooling represents something that has to be handled every changeover. This is an opportunity for error, non value add time, adds cost to future programs, and is an immutable barrier to zero-changeover.
- Where hard tooling is unavoidable:
    - Standardize interface points across machines for interchangeability
    - Provide for tool-less changeover
    - Design locating and guiding mechanisms in such a way that no adjustments are required on changeover.
- Specify equipment that provides programmability for all process variables.
- Avoid analog mechanical adjustments - as in sliding a stop to a position on a scale and locking it. Analog adjustments are inherently more variable from day to day, and person to person. This variation ultimately affects quality. Better to provide a discreet adjustment or to make the adjustment a programmable motion.
- Try to fully automate change-over steps. This reduces the time and error associated with manual hardware change.
- If change requires a human to switch hard tooling, all change tooling should be clearly labeled for human readability and identified with an error proofing identification system such as RFID, a sensor array, or ID jumpers in any electrical connectors.
- The more mechanically agile a system, the more it can be controlled through software. A zero-changeover system will be completely adjusted by software parameters.

In sizing up the application, it's natural to lock onto what's different about your products and processes. With some discipline, you can learn to focus on what's similar. With clever engineering and quick-change end of arm tooling, the same robotic assembly cell can be used to screw together one product, snap together another, and dispense adhesive on yet another.

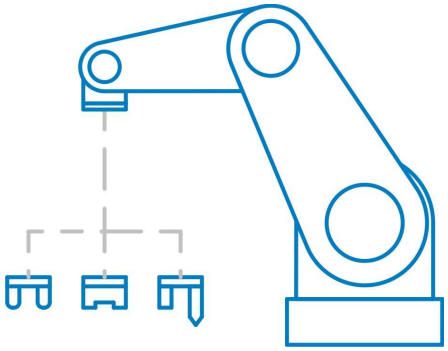
Agile Components

Here are just some of the components that can be creatively combined to achieve the design objectives that lead to system agility.

Robots

Robotic manipulators offer a high level of agility as compared to fixed automation. It is possible to combine several process functions, as needed, into one robot. The use of commercially available quick-change tooling adapters dramatically enhances the flexibility and ease of re-deployment of a robot arm.

The real value of a robotic manipulator is in its ability to accommodate surprises.



Robot with Automatic Toolchange Offers Incredible Agility

Vision Inspection & Verification

- Confirmation of correct part loading before initiating a cycle. Especially important in high model-mix processes. Color matching ensures correct color components will be assembled together.
- Check a part characteristic before passing it to next step.
- Detection of missing or mis-oriented components, absence of dispensed adhesive or grease in critical areas
- Presence, placement, and readability of barcode label or direct part marking.
- Use a robot mounted camera to inspect multiple areas of a part.

Vision Guided Robotics

- Reduces or eliminates need for fixed tooling, precise dunnage, or manual loading/unloading.
- Programmatically adapt to a wide variety of parts and process parameters.
- Respond easily and quickly to product changes
- Avoid cost and lead times associated with fixed tooling.

Servo Grippers for Robots

A robotic gripper that knows it position is a powerful thing. Torque feedback and finger position feedback allows the system to confirm proper part grip and even confirm the part type that has been picked.

Beware the Agile Imposters. The open loop gripper acheives a false sense of agility by ignoring all data. "The porcupine" is an actuator bristling with sensors to detect a multitude of discrete, known parts. Good agile solutions are about being prepared for the unknown. Avoid having to cobble on and maintain yet-another sensor. Avoid the porcupine.

Agile Part Presentation

Using a robot as workpiece positioner has inherent flexibility. This part-to-process topology works especially well for single-point operations such as dispensing, resistance welding, laser processing, punching, and some assembly tasks.

Programmable Locating Features

Programmable locating features are a low cost means to provide errorproof, instant changeover. A side benefit is that locating features can be made looser, tighter, or shifted on the fly to make process improvements.

Agile Tooling

- Locator pins and clamps allow tooling items to be combined on interchangeable tooling plates. This ensures that the machine remains generic while the tooling contains all of the part-specific features.
- Tool-less changeover minimizes downtime
- Built-in ID system to ensure correct tool is in place before cycling
- Pneumatically operated shot pins and clamps eliminate variations in clamping force that are experienced with thumbscrews or other fasteners.
- Couplings that engage pneumatic, hydraulic, and/or electrical signals automatically when tooling components are installed.

Agile Control System

All that mechanical agility is useless without the proper machine controls. The programmable parameters required to run a job must be stored in a centralized, easy to manage operator interface. This captures best practices to ensure consistent production parameters are used every time a job is run.

Implemented in this way, the control system is self-documenting. This is particularly useful when infrequent jobs, such as service parts, must be produced. Scrap savings alone from the resulting consistency often pays for any cost premium associated with Agile automation features.

Choosing an Automation Partner

Choosing a supplier by requesting 3 quotes and selecting based on acquisition cost does not result in a system that can deal with today's manufacturing reality.

The nature of Agile automation is that a small additional investment yields a disproportionately high return when one expands the ROI calculation to include the strategic and operational benefits described earlier. In the traditional 3-quote process, features important to machine agility are removed by suppliers desiring to present the lowest possible cost figure.

In the traditional 3-quote process, features important to machine agility are removed by suppliers desiring to present the lowest possible cost figure.

If you desire a system that is agile, the first step is to interview an automation company much the same way that you would an employee. If the company does not have a philosophy of designing agility into their machines, you will not be able to force it on them.

Once you have found an automation builder with the desired culture of agility, productive conversations can begin concerning the equipment required for your plant. You can proceed with confidence that you are not being steered in the direction of low price at the expense of your strategic and operational objectives.

Get Agile Now

There are opportunities for the application of Agile automation in every plant. Start with the most straightforward opportunities. Ideal Agile automation candidates have one or more of the following characteristics:

- Short to medium production runs of similar products.
- High mix production.
- Incoming product comes to process in a variety of dunnage containers/pallets.
- Finished goods have various pack-out requirements based on customer.
- Process that currently suffer from long changeover times.
- Processes where changeovers introduce unacceptable variations in output quality.

When exploring parts and processes that might be combined into an agile production process, focus on the similarities. Often you'll be surprised at how seemingly very different parts make great candidates for combining into an agile production system.

Spread the message to others in your organization. The broader the participation in your agile transition, the greater the benefit. Once the members of your team understand the benefits, all that remains is to get agile before your competition does.

[1] 2006 China labor rate: U.S. Dept. of Labor *[2] pluup.com automotive database*

Q&A

Q: Are you saying that I should add thousands of dollars in cost to my project for flexibility that I don't need to produce my product?

A: In the overwhelming majority of cases: Yes. That is exactly what we're saying. If done correctly, you will save money and derive a long list of indirect benefits. The idea is not to indiscriminately add bells and whistles to a machine. It's about investing the work and creativity required to gain the maximum amount of flexibility for the appropriate level of investment. It's important to consider the many indirect benefits discussed in this guide when evaluating cost/benefit of a given feature.

Q: If Agile automation is such a great idea, and represents the core of your company's competitive advantage, why are you opening your playbook for the whole world, including your competitors, to see?

A: Applying Agile automation ideas is a lot like employing Lean or Six-Sigma techniques. You can learn the basic ideas in an afternoon. However, mastery is a continuous learning and improving process. Because Kinemetrix has a 10-year head-start on its competitors, it benefits us all to share openly in becoming as agile as possible to remain competitive in the years to come.

Q: Okay, I can see this is the way to go. Now how do I get everyone from my team to purchasing to senior management to buy-in?

A: Kinemetrix is available as a resource to educate the stakeholders in your organization who must buy in to the agile approach for it to be successful. Sharing this guide or visiting our website are quick ways to spread the word. In many cases, we can come to your facility to make a presentation. There are resources and contact information below to help you explore how we can help you champion the agile message.

Often, all that's required is an internal champion who "gets it" and the right project. Once a piece of Agile automation is in operation, the myriad benefits become so clearly evident that that there's no turning back.

RESOURCES

This presentation was brought to you by:

Kinemetrix is always interested in discussing how Agile automation can improve your manufacturing operations. To arrange a meeting or presentation at your facility please contact:

Chris Gullo
Business Development Manager
859.381.9937
cgullo@kinemetrix.com

Kinemetrix
165 Trade Street
Lexington KY 40515

You can always learn more at:

Kinemetrix web site: www.kinemetrix.com

FANUC Robotics "Save Your Factory" program: www.saveyourfactory.com

Thank you for your time and interest. We look forward to seeing how Agile automation has helped you to succeed.

Sincerely:

Jim Peyton

President

KINEMETRIX

(859) 381-9937

Authorized
System Integrator