CONSIDERATIONS FOR SEAMLESS INTEGRATION OF AUTOMATED MACHINING SYSTEMS

MAKINO

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CONSIDERATIONS FOR SEAMLESS INTEGRATION OF AUTOMATED MACHINING SYSTEMS

Automated machining systems have become a key component to the success of U.S. manufacturing. They have been applied and configured to meet a variety of needs across nearly all industries. Some are designed to boost general production capacity, while others are intended for improved flexibility. No matter the system's configuration or the parts being produced, the reason companies are turning to these technologies remains the same: global competitiveness.

Despite the many benefits of automated manufacturing systems, their complexity is oftentimes intimidating to first-time investors. In many ways, these concerns are justified. To effectively define, plan, justify, select, implement and execute a full system integration can be a daunting task for those who are unfamiliar with the process. As such, manufacturers must familiarize themselves with this process and the key considerations for a seamless integration.

PLANNING FOR AUTOMATION

Manufacturers must first know what they would like to accomplish through automation in order to determine how their system should best be configured. These questions should be answered:

- What type(s) of machining needs to be done (5-axis, 4-axis, aluminum or titanium)?
- What are the features and required machining processes?
- How many parts are typically produced? Is the company expecting to meet volumes of 25,000 pieces per year, or 1.5 million pieces per year?
- What are the part types and mix? Are the parts from the same casting, or are they totally different shapes?
- Does the manufacturer want to move parts, fixtures or fixture plates within the automation?
- What benefits would the company like to experience as a result of automation—increased machining efficiencies, unattended operation or reduced labor costs, better ergonomics, or the elimination of hazardous work conditions?

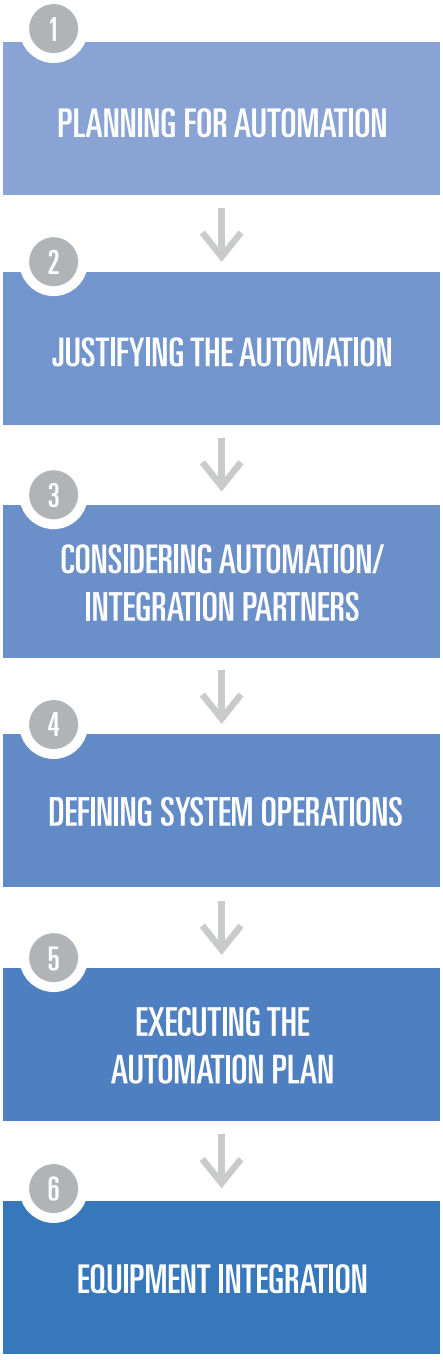
When the company can answer these questions, it is ready to begin the planning process.

One of the first steps in employing an automated machining system is to plan how the machining cell would look and the direction the system would take including part volumes or types. The production environment in the manufacturing facility usually dictates the type of automation system and the mix of machines installed. The most common types of automation systems
are typically classified into these three areas:

- High-volume production
- High-mix, low-volume production
- Die/mold automation

As the production environment of the business is identified and planning begins for the equipment to be included in the system, project leaders should also consider future expansion. It's important for a business to plan its automation system with an eye on growth so that when it's time, the addition fits well within, or can be extended from, the existing automation cell.

PROCESS FOR SEAMLESS INTEGRATION



HIGH-VOLUME PRODUCTION

HIGH-VOLUME AUTOMOTIVE ENGINE BLOCK PRODUCTION CELL WITH ROBOT MANAGEMENT AND VISION SYSTEM.

Typically employed in an automotive parts machining environment, where the same part is being manufactured over and over in quantities by the thousands. It is characterized by a highly customized system, where each one of the systems is unique for the part or process, and typically involves a robot or gantry system that services the machining center. There is direct part handling in the machining centers, and serial machining processing, where the parts are passed between machining centers for operations.

HIGH-MIX, LOW-VOLUME PRODUCTION

Employs low-volume production, but with a high mix of parts being produced on the machine(s). They are typically found in the medical or aerospace industries and often include standardized automation with a system controller to control the flow of parts production. A transport mechanism may move fixtures between machines, or move a fixture plate between tombstones. This is a flexible system that accommodates multiple part types moving across the same machining center.

AEROSPACE PART PRODUCTION IN AN MMC-R FIXTURE PLATE DISTRIBUTION SYSTEM.

DIE/MOLD AUTOMATION

ROBOT-TENDED SINKER EDM CELL WITH AUTOMATED LOAD/UNLOAD OF TOOLING AND WORKPIECES.

Usually employed in mold and electrode machining environments and typically includes standardized automation traveling between machines within a work cell. A cell manager may coordinate the flow of work through these cells, which often includes EDM and milling machines with a single (often Cartesian-style) robot servicing these machines.

JUSTIFYING AUTOMATION

It is crucial for any owner or employee driving the automation process to develop a strong business case defining the ways automation can benefit the company. This business case is especially critical if the company is new to automation. These goals can sometimes include efforts to increase machining efficiency and capacity in order to gain extra revenue potential, or to save direct labor costs and setup times, or improve quality by eliminating scrap.

The internal team needs to understand and accept the changes required to support the automation, along with the new responsibilities that these changes bring to their roles within the organization. All concerns should be addressed at this point to ensure the company is capable of executing the proposed changes. Many employees who go through the implementation of automation say they have become energized by the process improvements that automation brings, and they are excited to learn new skills. Automation leads to increased capacity, thus many operator roles are redefined or retasked to other areas. Many times when the new automation project is completed, operators ask specifically to work on the automated cell because of its additional capabilities. The operators typically appreciate that automation handles the repetitive tasks, providing them with time to do more productive tasks, such as checking parts or maintaining the equipment or production area.

Once the automation project has buy-in from the organization, creating the right internal and external project team is vital to its success. Internally, the team should include a project leader to be the automation advocate. Manufacturing and process engineers, as well as operations personnel, are also key players. Together they coordinate with other engineering aspects such as mechanical, controls and software on the project. Representatives from maintenance, quality and safety should also be involved. It's crucial that all disciplines understand the company's goals and each individual's role in supporting the project.

As part of the internal planning process, team leaders should consider whether or not the company's machining process would benefit from logistical changes that better accommodate the flow of the automation. For example, being open to rearranging the shop's floor plan might bring opportunity to improve the operation. Changing the way the part is fixtured (or how many parts are actually on a fixture), revising the way quality is monitored, and looking at how often inspection is performed can all improve reliability and simplify the operation of an automated system.

CONSIDERING AUTOMATION/INTEGRATION PARTNERS

Selecting the right suppliers and integration partners is critical, and it can determine how smoothly the next phases proceed. At this point, manufacturers have the option to manage the integration process themselves or seek a single-source provider. Given the complexity of modern automated systems, it is highly recommended that manufacturers work with a supplier able to coordinate all aspects of the integration process, including third-party equipment. A single-source supplier should be able to handle all aspects of the project, enabling the company to focus its attention on larger objectives—such as the next customer opportunity, internal continuous improvement processes or optimizing business continuity. After all, time is money.

When selecting an automation partner, the products and solutions offered by each supplier should be carefully considered. Whether or not the company has advanced expertise is important. Past manufacturing experience with automated systems is essential, and the supplier should be able to share examples of automated machining operations successfully facilitated.

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It is also imperative to review the types of products the supplier offers, and whether or not the supplier has the electrical, mechanical, engineering and robotics knowledge required. The right supplier should be capable of handling these types of integration services on behalf of the business:

- Project management with a single point of contact
- Specification/design reviews
- Drawing approvals
- Mechanical engineering
- Robot EOAT design
- Layout design
- Controls engineering
- Programming of robot/cell control
- System runoff support at customer site
- Installation/start-up support
- Final documentation
- Site supervision
- Post-installation support

Manufacturers should evaluate whether or not all automation components can be purchased from one supplier, or if, for example, a robot will need to be obtained from one partner and conveyor systems from another. A single-source supplier who has knowledge of third-party equipment can provide recommendations for the entire system, streamlining the purchasing process.

Other considerations include whether or not the manufacturer's solution offers the best return on investment (ROI) for the automation endeavor. Ergonomic issues and product life should also be weighed—such as how long a product is expected to be made and whether the automation supplier is able to meet a business' changing needs.

Automation has many levels and depends on the application. Sometimes a supplier may recommend starting simple in order for the business to become comfortable with the process of automating.

In addition, it is important to decide how much work is to be handled internally, and how much work the automation supplier must manage. A single-source supplier is responsible for the entire system and can easily consolidate the machines, fixtures, pallets, conveyors and robots. This supplier is the single point of contact throughout the project, coordinating activities between all parties and managing the project schedule and installation. Such an approach means that the internal project manager does not have to handle everything on his own, can concentrate on other things, and that various suppliers do not resort to finger-pointing later about who is responsible for what issue.

Early in the project, be sure to determine the criteria used to accept the automated system. All of these expectations should be dealt with in the vendor agreement to ensure success down the road.

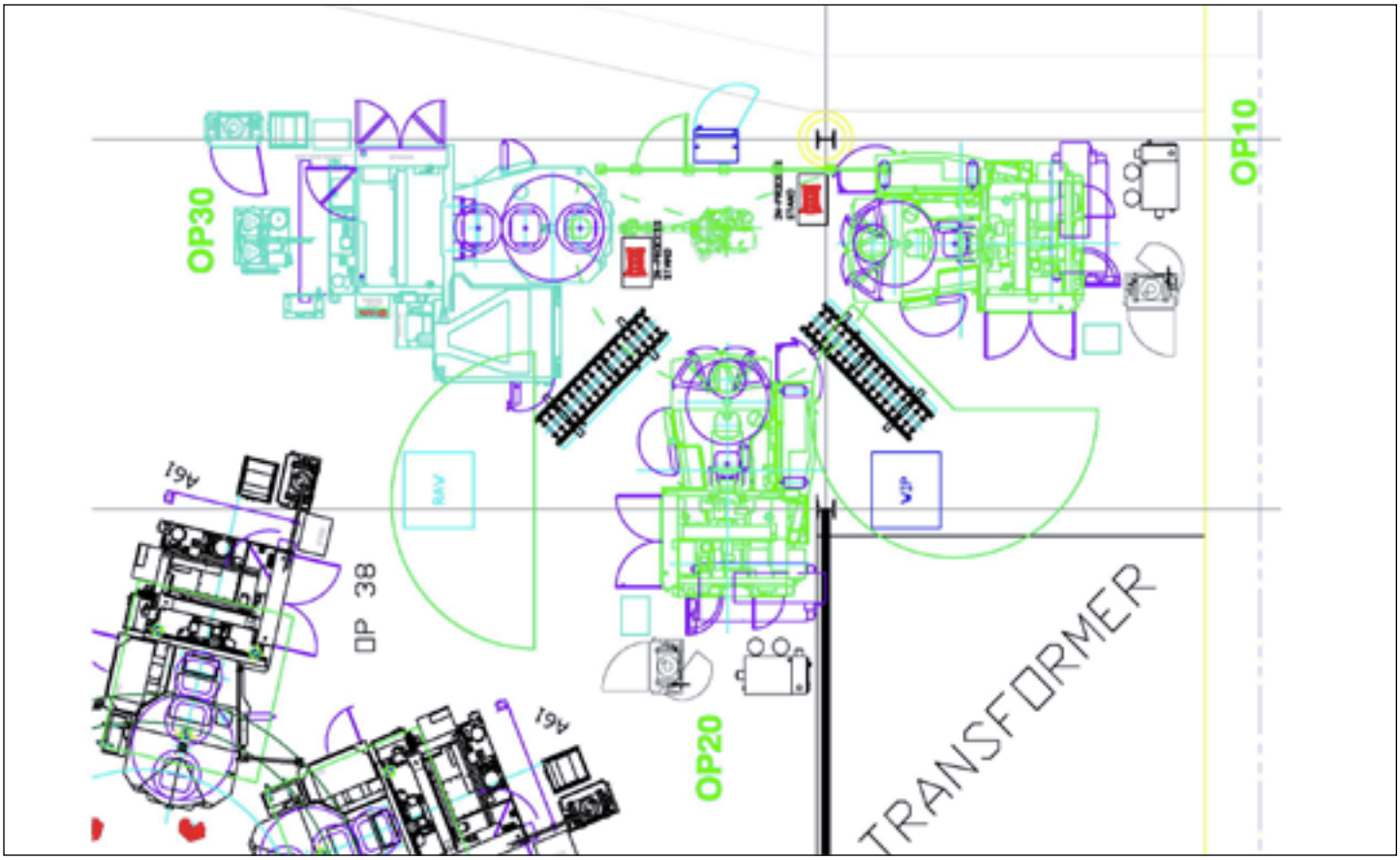
FULL-SERVICE TURNKEY AND INTEGRATION SERVICES

SINGLE-SOURCE SUPPLIERS ARE AN EXCELLENT RESOURCE FOR SEAMLESS INTEGRATION FROM PLANNING TO PROCESS ENGINEERING, AND FINAL INSTALLATION.

DEFINING SYSTEM OPERATIONS

Once the internal and external partners are identified, planning can begin for the operation of the automated system. This step needs to be a collaborative process involving all parties.

FLOOR PLAN LAYOUT OF MULTI-OPERATION MACHINING CELL

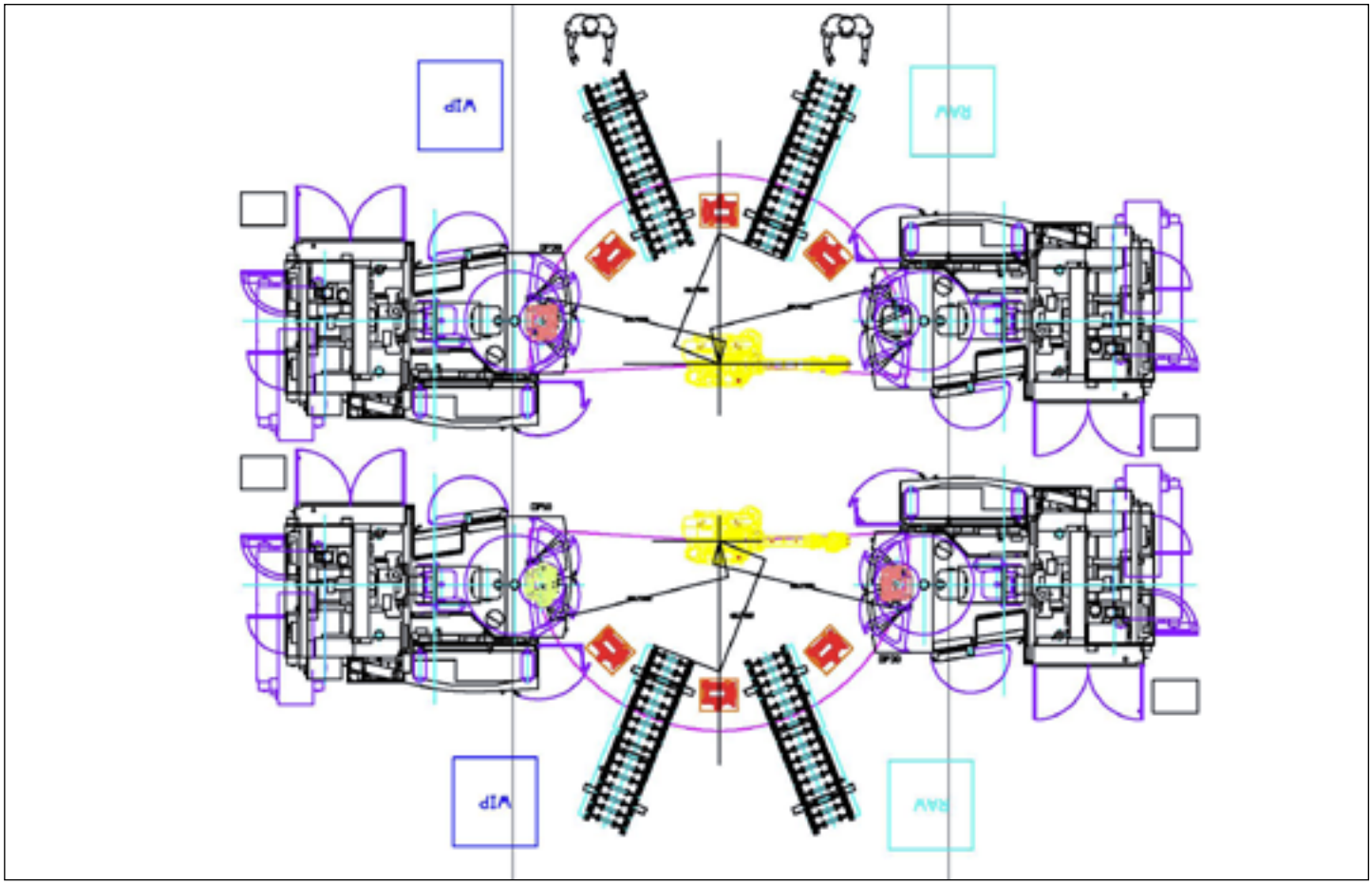


DEPENDING ON AN INDIVIDUAL MANUFACTURER'S NEEDS, AUTOMATED CELLS CAN BE DESIGNED FOR END-TO-END PART PRODUCTION OR SPECIFICALLY TAILORED TO SPECIFIC OPERATIONS.

First, some considerations surrounding cell layout must be verified. The automation cell should be designed in a way that optimizes the use of floor space. The flow of material through the cell must also be decided—such as where the raw material is introduced into the cell, and the location for the finished product. Specifications for the production volumes should be known, as should requirements for additional capacity. If additional capacity is a possibility, a plan for future expansion should be in place. This plan should include the needs for future machining centers, material handling and additional part types.

If an operator is no longer standing at the machine(s) as a result of unattended operation, then the machines should use machine processing monitoring functions, such as tool-life monitoring and tool-breakage functions. With these monitoring functions, the machining equipment could detect when a tool is becoming dull (reached the end of its life), and if a tool has broken during the machining process. Many shops employ other functions, such as part probing, to monitor the process and to find the exact location of the part before the machining process begins and to use part-seat detection to ensure that the part is loaded properly in the fixture. Both help to ensure the automated system is producing quality parts.

FLOOR PLAN LAYOUT WITH WORKFLOW



PROPER CELL PLANNING ENABLES MANUFACTURERS TO EFFICIENTLY MANAGE PRODUCTION WORKFLOW.

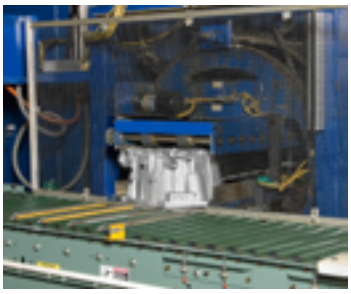
In an unattended environment, process checks should be conducted to manage the quality of the part. If the process is capable enough, a company can ultimately reduce its costs on part inspection within the automated system. It must be determined how often inspections take place, and on how many parts. Individuals should be identified who will understand and maintain this process. They must know how parts are rejected from the system, and be familiar with the process in which operators are notified (and how quickly they react) if something goes wrong. The company should have a plan on how scrap is identified, tracked and quarantined within the system. Standards must be defined concerning the restart of the machines after interruptions to the production processes.

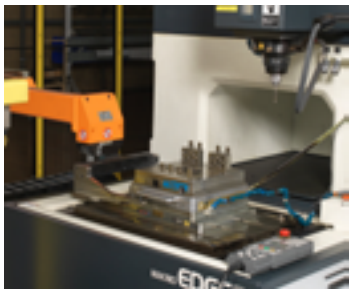
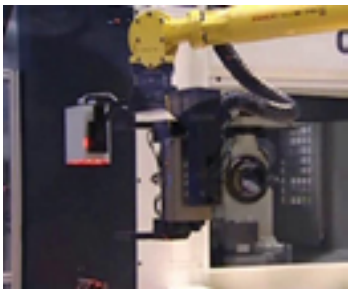
Scheduled maintenance should always be part of the plan to support an automated machining system. Checks should be conducted periodically to verify that the process is still within specification and that the parts coming off the machine are of good quality. It must be decided if operators should perform these checks while the machine is online or offline, and if they are going to be manual or automated checks.

AUTOMATED TECHNOLOGIES AND AUXILIARY PROCESSES







Other questions to ponder involve the use of various automation technologies and auxiliary processes, which are noted below:

- How is the work going to be transferred within the cell? Will it require a pallet-handling system, or will parts be handled directly by the automation?
- Will quick changeovers be a factor? Is standardized fixturing necessary?
- Are robotic vision systems required for part inspection, loading/unloading and/or identification?
- Will parts need to be automatically marked, identified and tracked?
- Is it critical for parts to be cleaned before leaving the cell?
- Will secondary operations such as deburring be an automated feature managed robotically?
- Is online inspection necessary to ensure the quality of all parts leaving the cell?
- Is a robot gripper quick-disconnect mechanism necessary for handling multiple part/pallet types?

EXECUTING THE AUTOMATION PLAN AND INTEGRATION

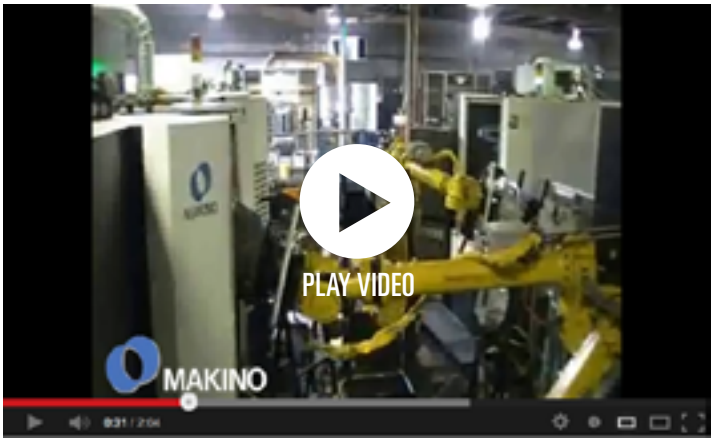
This first step in executing the automation plan should be a detailed review of all project designs, preferably using the benefits of solid modeling design tools. All approvals must be coordinated so that when a change is made to one design (a robot gripper, for example), the other designs for the tooling and equipment within the automation system are checked for possible effects by the design change (such as the machine fixture). When a single-source supplier is employed, that supplier is responsible for ensuring these checks of the designs are completed, eliminating potentially excessive delays to complete the overall design checks.

Throughout the project, predetermined milestones should be in place to confirm tasks are progressing as they should. Early on, the program manager/coordinator/leader should be identified. This is the person who sets the milestones, coordinates the on-time delivery schedule of multiple suppliers, and takes ownership and ensures that the milestones for on-site installation are reached. Sometimes, the end-user may not be able to assign a dedicated project manager who coordinates these activities, simply because there aren't any personnel with the time available to take on these extra tasks. If a single-source system supplier is used, the supplier determines the milestones for progress and is involved in all aspects of the project—coordinating multiple suppliers on site and making sure everything shows up and is installed on time. Good supplier relationships are key to successful installation, and many times the suppliers on the project appreciate a single project manager and respond more quickly to a designated project manager.

Prior to installation, all members of the integration team should know when each component is scheduled to arrive, and where these components are to be located on the shop floor. This coordination surrounding the delivery of equipment for an integrated/automated system is required for the machining centers, machine fixtures, robots, conveyors, etc. Delays in delivery for even one piece of equipment could affect the installation/integration of other system components into a complete system or cell. For example, if the machine's fixtures are late, the robot can't be programmed. Handling such logistics can be a daunting task, but with a single-source supplier, the scheduling and execution of the program can be better managed and coordinated.

AUTOMATED SYSTEMS IN ACTION

AUTOMATED MANUFACTURING SYSTEM WITH ROBOTIC DEBURRING AND VISION SYSTEM.



AUTOMOTIVE PRODUCTION ON A FULLY AUTOMATED a81 CELL.

During the installation of the automated system, it is critical to involve all internal resources in the installation—including the engineers, maintenance personnel and operators. Everyone should obtain as much experience as possible while the supplier's installation team is on site. Adequate training should be conducted in order to review operations, maintenance and troubleshooting, which are all important to the future success of the automated system.

COMPLETED CELLS AND SYSTEMS

GANTRY ROBOT CELL FOR REPEATABLE VOLUME PRODUCTION.

MMC2 FLEXIBLE MANUFACTURING SYSTEM FOR 24/7 MACHINING.

A specified acceptance test run should be conducted along with a complete functional check of the automated systems. It should be verified that the full capabilities required are in place and that no weak points exist. Once the start-up has been initiated and production begins to ramp up, it is a good idea for local personnel to continue to familiarize themselves with the operation of the automated system in order to provide support for continuous improvement of the system. Learning how to maximize equipment efficiencies increases the future success of the system, so it must be ensured that all aspects of the project are moving as they should be. Once complete, a final acceptance review should take place.

If the supplier has guaranteed a throughput or takt time on the automation system, a throughput test should confirm the automation system is performing per the requirements. The end-user should examine the warranties provided with the system with those suppliers responsible for supporting those warranties.

Supplier expectations for the final aspects of the program installation and startup should be communicated and understood by all parties at the beginning of the project—especially those expectations surrounding the level of assistance the supplier(s) should provide after acceptance of the system. Post-installation, it's very important to have proper documentation in place to maintain and support the system. A spare-parts inventory should be identified, and preventive maintenance schedules should be maintained to keep machines operating at peak efficiency.

ADVANTAGES OF AUTOMATION

Businesses that have employed automation systems typically enjoy many efficiencies. First are the reduced manufacturing costs that result from lower direct labor costs. Robotic automation enables a single operator to more efficiently handle several machines at once.

Machine efficiencies for manually operated systems are typically around 85 percent utilization, while the machine efficiencies for an automated system are typically above 90 percent, approaching 95 percent utilization. Machine counts required for known part production volumes may be reduced due to the increased efficiencies realized from automated systems.

Ergonomic issues that result from workers carrying heavy parts can also be addressed with automation. There is increased flexibility of shop resources, with production hours rising through unattended machining, or with 24/7 operation.

For job-shop types of environments—which have many part types and low part counts—automated systems often bring higher productivity due to the faster part turnaround resulting from the elimination of direct setups on the machines. With less time between part setups and multiple jobs running concurrently, there is more throughput generating additional revenue. Customers enjoy shorter lead-times. Ultimately, the business is able to react quickly to market opportunities and can better compete globally due to reduced labor and part expenditures.

Increased revenue potential also comes from additional machining capacity. Imagine the profitability potential if the machine utilization is improved by only one hour a day. While the number sounds small, it can have a significant impact on the shop.

For example:

- The business sells its machining time at $75/hour and has 250 days a year in available production.
- It increases production time by one hour/day.
- This extra hour per day yields potential additional annual revenue of $18,750.

With the shop running more efficiently, the business is able to accept more jobs and diversify applications. Because the company can do a better job of tracking the work that comes through the shop with an automated system, the machines can run faster, longer and with improved turnaround. A shop that was reorganized for improved tracking and flow of work can also see a more efficient manufacturing process.

Finally, many customers also have an improved perception of the business when it employs state-of-the-art machining. Modernization through automation shows a company's commitment not only to their customers' growth, but also their own.

CONCLUSIONS

- Seamless integration of automated system must begin with proper upfront planning. Expectations must be set in terms of production volume and part variety before a proper system type can be identified.

- Investments in automated systems affect more than just the shop floor. During the planning process, it is important to involve leadership from all areas of an organization to ensure the correct decision is made and that all areas of the business are prepared for the shift in production.

- Selecting the right suppliers and integration partners is critical, and can simplify all aspects of the project. This is especially important for first-time investors in automation.

- Determining automation technologies and auxiliary processes must be accomplished during layout procedures to ensure efficient workflow. Be sure to verify all requirements for a completed part.

- Execution begins with a thorough review of all project designs, as well as establishing milestones. Take time in the scheduling process to ensure that all components are set to arrive at the appropriate times and adhere to established milestones.

RESOURCES

ONLINE:

www.Makino.com

ONLINE SEMINARS:

Automation And Integration Machining To The Max

Simple Automation

Utilizing Vision Systems With Machine Automation

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