When Work Cells Work for Machine Tools

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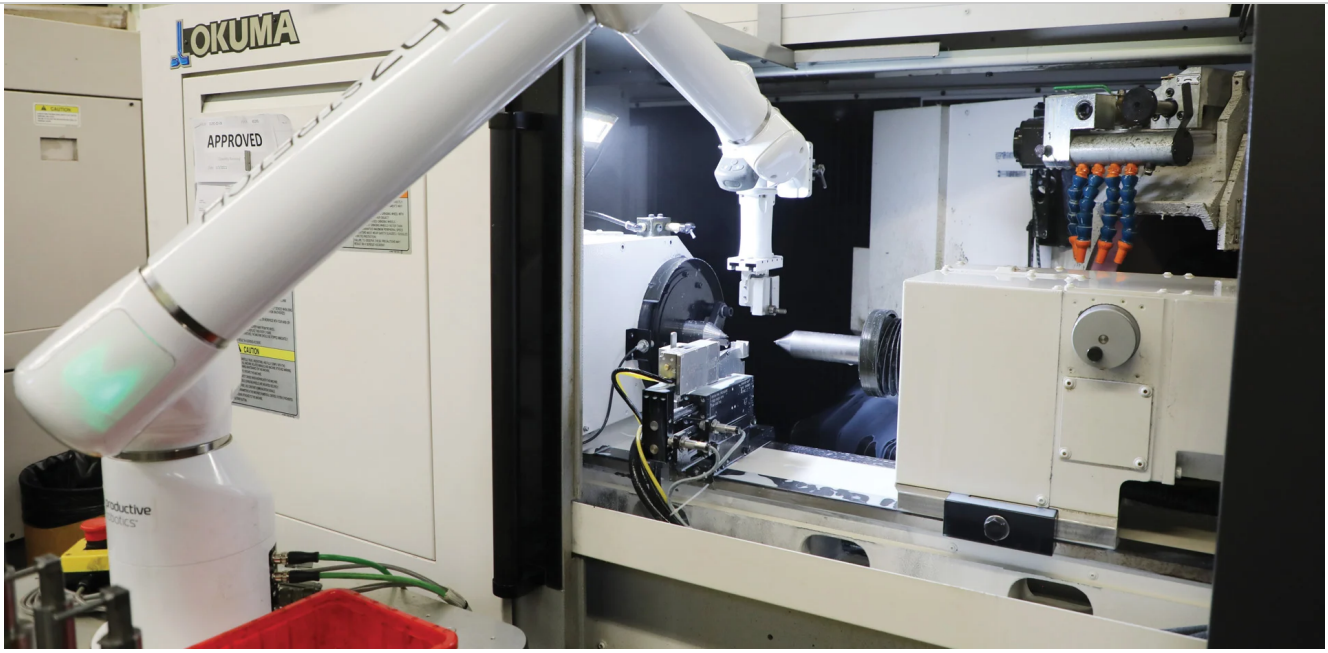
Scope of work, automation, ROI and other matters of note. Or, how many widgets do you want to make—and how fast?



Small and medium-sized companies can get started in automation with an easy-to-learn, easy-to-teach collaborative robot that does simple machine tending. Proper training is essential. (Provided by Absolute Machine Tools)

Machine tool cells feature robot-linked automation that stops short of the highest throughput flexible manufacturing cells (FMS) provide. Variety is their hallmark. Machine tool cell configurations possible with robotic automation includes shops with high mix/low volume requirements as well as cells with high-volume throughput requirements.

But how to choose investing in a work cell with a machine tool, and which configuration? It's best to understand the fundamentals first.

Machines can be tended and linked to produce the same parts in serial production or perform multiple complex machining processes on individual parts. First-time adopters of automation as well as experienced shops can benefit from the expertise available from machine tool builders, robot and automation suppliers and the integrators who package them into a productive solution. In this article, leading machine tool automation companies weigh in on what to look for when getting started in adopting machine tool cell technology.

The starting point for a shop to consider if a machine tool cell is the right approach is usually when the goal is how to produce the greatest number of parts efficiently. Both smaller job shops and large production shops should ask themselves the same questions as the configuration is determined, according to Matt Gifford, national sales manager, Mitsui Seiki USA, Franklin Lakes, N.J. What kind of work? Annual quantities of part numbers? Are there related part families? What types and quantities of machines are needed and available to

Titanium components that weigh 2,450 lb (1,111 kg) before machining and 10,000 lb (4,535 kg) with fixtures are machined with three five-axis Mitsui Seiki machining centers equipped with high-torque spindles and a 1,900-mm table designed for the application. (Provided by Mitsui Seiki USA)

According to Gifford, the combination of differing types of machines in a cell has become easier to integrate in recent years. It is still most common that the machines chosen for the cell are configured alike and from the same builder due to ease of integration and similarity.

Other combinations are typically machines that can use the same pallets among them. For example, if you have large parts (one meter or larger pallets for example) that use horizontal machining centers with a VTL lathe and inline CMM inspection, the pallet receivers need to be the same on all machines. For smaller parts it works well to load multiple part varieties for a “just in time” production system, keeping spindle utilization high. This scenario works best when using small pallets that can fixture a large variety of parts, and with the same receivers on a variety of machine tool configurations, including turning, deburring, washing, inspection and more.

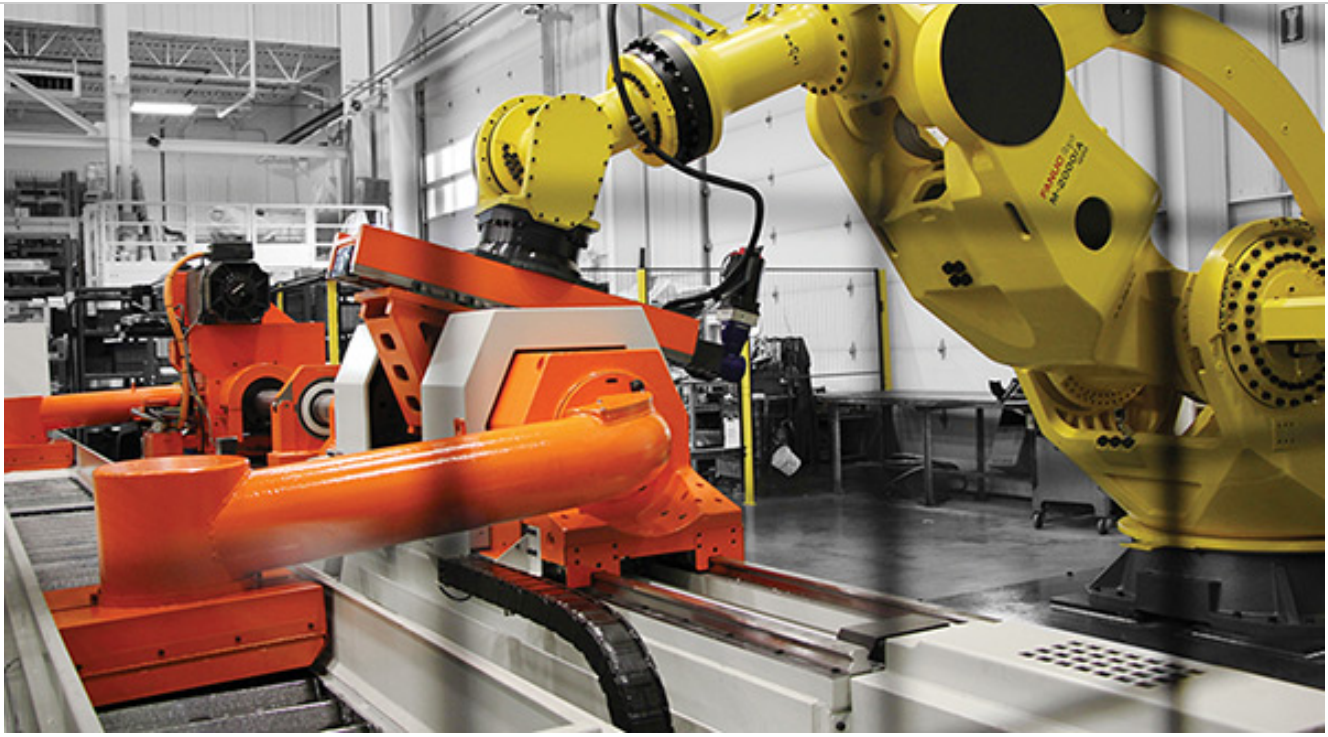
Great progress is being made for high-mix/ low-volume production, which is common in job shops and any production environment functioning with a lean strategy. Today’s advanced cell controllers brilliantly manage and monitor all the aspects of the cell and can be integrated

Most machine controls are PC-based, easing the ability to integrate and connect the machines. Advanced cell controllers today have the sophistication to marry the different machines. The challenge, however, is most shops have a variety of machine tools with different ages up to 20 years old or older. It's better to plan replacement strategies by bringing in a new cell to replace older equipment. Even so, there is still use for the legacy equipment. Sometimes one piece of older equipment can be used to prep parts with a qualified service, such as for mounting into a fixture, and then the balance of processes can be automated into cellular production.

It is not difficult to manage if you use a common PC to manage the data. Typically, each machine can operate as a stand-alone operating system and then the scheduling, reporting and workflow can be managed with the centralized PC cell controller. There are companies that specialize in these types of systems, or a system integrator can manage the entire project.

Gifford noted that his company often performs this role and takes the lead on cell configurations. "There's a lot to it and experience is a must for the optimal outcome," he said. "Plus, companies need to look ahead and consider future milestones for automation so that everything put in place now has the capability to connect with future installations. Happily, most current systems are designed to be modular and expandable as a company's needs grow."

Todays "teach" method of robotic programming has dramatically made it easier to integrate material handing requirements for machine tools and related handing requirements. The biggest challenge is safety around the operating environment. Many systems need to be gated with safety locks for system maintenance and repairs when individuals are inside the motion-controlled areas of the cell.



Robot loading a heavy part. (Provided by UNISIG)

Expectation for an acceptable ROI for a cell with multiple machines depends on a company's write-down (reducing an asset's book value to a fair market value) strategy. On an accelerated write-down of seven years the goal is to keep the ROI between 18 to 60 months. This is usually for projects funded for under $4M. For larger projects with a typical straight 12-year depreciation, the ROI expectation may run longer. It also depends on a company's EBITDA strategy (earnings before interest, taxes, depreciation and amortization.) As a rule, the ROI on any type of manufacturing cell should not be any longer than the time of depreciation. Most well-configured manufacturing cells will have a ROI of 2 to 3 years due to the increased production.

Machine Tool Cell Starting Point

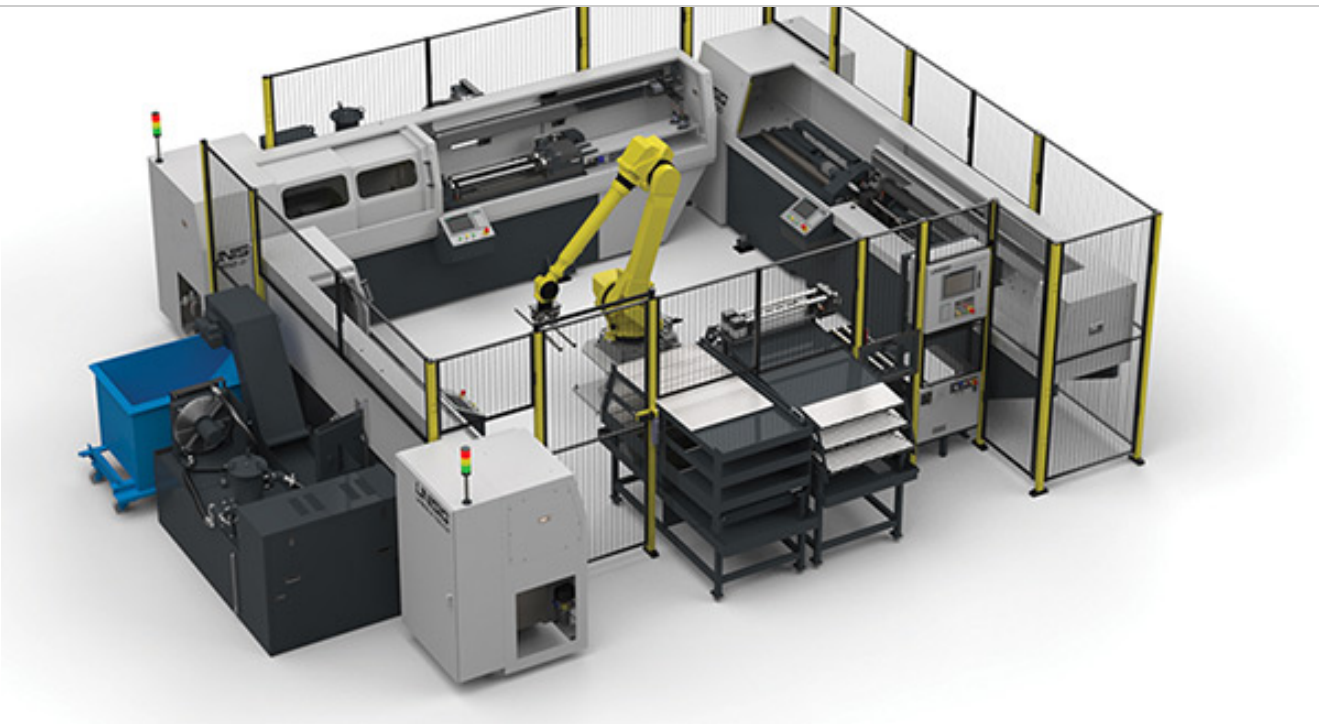
The basics of automating machine tool cells are outlined in a conversation with Dave Zunis, director of service and applications engineering and Courtney Ortner, director of marketing, A+ Automation Team of Absolute Machine Tools, Lorain, Ohio. They advise beginning with a definition of the scope and purpose of the automation project that is clearly understood by both parties. They think it important to pose the following questions: How many widgets do they want to produce? What is this automation going to do for them—increase production? What ergonomics are you trying to change or improve?

Advanced bin picking automation. (Provided by KUKA Robotics)

do they have the right machine tools? Do they have adequate capex money to purchase the machine tools if they don't have them? Do they need us to assist with deciding on the right machine tool? A plan needs to be developed. That is where machine tool dealers and integrators come together, hand in hand, to help the customer with this process," said Dave Zunis. Absolute Machine Tool performs all three functions: Choosing a CNC machine, selecting tools and integrating them into the cell.

Automating a machine tool cell can streamline and optimize what had been a manual operation. Zunis said that questions about ROI often come up at this point. "Obviously, we can't always tell them what their ROI is, but we can give them what the cost to integrate is going to be. They must weigh it internally by adding in the cost of an operator, or multiple operators, benefits, and all other overhead the company has with people in place. They also need to consider their current throughput. In the end, based on the numbers they give us about the number of parts they are going to produce, current cycle times, current takt times, including the robot [time] to load/unload, we should be able to give them an ROI estimate."

The most popular automated cells in Absolute's lineup are machine tending with arobot loading and unloading a mill or a lathe. A recent automated cell involves a firearms manufacturer who started a new company to make gun barrels because he was having trouble getting them. The cell involves a robot loading a gun drill, taking the barrel from the gun drill to the reamer and from the reamer to the button rifling machine to finish the process. "A lot of what we see with machine tool cells is to eliminate the ergonomics of the repetitiveness of loading and unloading. Especially in this time with the shortage of workers it makes a lot more sense now than ever to automate," said Zunis.



Automated cells can be tailored to specific applications or standard pre-engineered off-the-shelf cells. (Provided by UNISIG)

“I get emails from small and medium-sized companies every single day telling me that they want to get into automation but they don’t know how to start,” said Courtney Ortner. “Those companies really need to look at starting off slowly. In the case of the gun barrel manufacturer, the owner was in a hurry to get barrels, so he needed to jump in with both feet. However, other small and medium-sized companies may not have an urgent need but instead have difficulty finding people for their workforce. I tell them that they need to start with an easy-to-learn, easy-to-teach collaborative robot that does simple machine tending and take the time to train enough people properly to teach the robot once the initial job is over so that the robot doesn’t sit idle. It’s important that they take advantage of our training as the integrator.”

Incorporating third-party devices and processes into the machine tool cell is becoming easier because of the increasing impact of IoT plug and play capability. “As an integrator we can incorporate peripheral equipment into the cell that is designed around the robot. Today, there are more manufacturers producing IoT equipment, such as tablet PCs with production apps that can run on them. We also use custom software or PLCs to integrate and communicate with peripheral equipment. Another plug and play item that is making headway is end-of-arm or end-effector tooling. For example, Schunk and some of your bigger robotics tooling companies provide a USB stick [of software/data] that is uploaded into the robot,” said Zunis.

pencils, sanders, polishers, and vacuum modules have made them plug and play capable. There aren't dedicated interfaces that are plug and play for CMMs yet, but I foresee it is going to happen in the near future because of the Internet of Things revolution," said Ortner.

Start with Robot-Ready Machine Tools

Machine tool cells can help solve the critical labor shortage facing today's manufacturers but getting started for shops using automation for the first time requires careful attention to selecting CNC machines, robot technology and cell integration. As a rule of thumb, anything that is well developed and reliable in a manual application is a candidate for automation in a machining cell, said Anthony Fettig, CEO, UNISIG Deep Hole Drilling Systems, Menomonee Falls, Wis.

"Just like in a manually operated machine, getting the basics right with feeds and speeds that give good chip control, designing efficient work holding that reliably locates the parts, and having a good plan on what order operations are needed will make automation easy to implement," Fettig advised. "To get started with automation, select machines that can be specified as robot-ready at the factory for easy integration into cells, which may include additional I/O, automatic doors, and additional sensors to monitor the machining process."

"Grouping families of parts together is a common strategy, and that is where a lot of early automation planning comes into play—how do we minimize changeover time and increase flexibility? There are several reasons to put multiple machines together," Fettig explained, "but in order to have good spindle utilization on all machines, the cycle times needs to be in balance."

Pre-engineered cells can automate a machine in one day. (Provided by KUKA Robotics)

“For example, there may be a volume requirement for parts with two machines performing the same processes. Two two-spindle machines with a robot means you effectively have a

and the long-term operating costs of the cell. Another example: In a three-machine cell you might have two two-spindle machines drilling a really deep hole and a third two-spindle machine drilling a shorter hole that takes less time. So you have four spindles feeding two spindles to get your balanced cell. That's the nice thing about these flexible cells—you don't have to commit to one very large dedicated machine," Fettig explained.

UNISIG develops machine tool cells for a variety of industries for precision machining shafts and workpieces for diesel fuel components, medical tooling, and plastic injection molds, among others. Medical industry applications include making shafts for orthopedic devices and drilling surgical instruments. UNISIG's gundrills and other deep-hole drilling and finishing machines are capable of drilling holes with depth-to-diameter ratios of up to 100:1, in a wide variety of workpieces. "We automate cells to drill parts weighing only a few ounces, but in other applications, parts weigh thousands of pounds and are still robotically loaded." said Fettig.

Robot choices range from DIY collaborative robots to high-speed industrial robots. "If a customer is going to integrate a collaborative robot on their own, they just buy the machines from us robot-ready and we support their project. The cells we provide use high-speed industrial robots to service multiple machines."

"When we start an automated cell project, we plan out the best arrangements of the machines, pick a robot or a series of robots and feeder systems and our engineers develop specific programs for that project. We either prove out the full system on our floor or do the integration of two or three machines together into a cell at our customer's facility," Fettig said. These industrial robots are quick and powerful. UNISIG is an integrator of FANUC robots. "In these cells, there is fencing involved for safety or laser scanners sometimes to protect operators from the fast-moving robot."

Automated cells are tailored to the specific needs of the project, and as a result, they tend to be costly on a first build because the engineering is dedicated to that exact set of circumstances. "Probably the most interesting trend for our customers is when we create a standard off-the-shelf automation cell. We have pre-engineered the robot, the effectors, fencing systems, in-feed and out-feed mechanisms and all they are doing is buying the thing that has value for them. We are replicating that same thing over and over for multiple customers so the bugs are already worked out and the cost is lower because the engineering is already proven. The cell can be quoted in a half an hour so the customers can consider options they otherwise might put off."

"It's a very friendly touch screen that's located on the outside of the cell. It features a single interface for the operator to run all three of the machines and the robot and the feeding systems. It allows someone who is a novice level machine operator to effectively restart cycles if something is set up wrong or if the robot is involved in a collision. They can bring the robot to a safe position and start programs without being a programmer. They can basically run the cell and see the status of the machines and never really enter the cell unless there's a changeover."

Automating Cells for Productivity

Automation keeps production going whatever time of day or day of the week, resulting in shorter lead times, higher productivity and faster return on investment. In fact, Eric Ostini, head of business development for GF Machining Solutions (GFMS), Lincolnshire, Ill., said that the significant initial upfront investment in automation is readily justified with the increase of production time from 2,000 to 6,000 to 8,000 hours per year.

GFMS's System 3R Automation provides the hardware and software to integrate pallets in chucks on machine tables to automate milling, wire EDM, laser and grinding machines. Capable of complex transfer movements and parts handling automation supplied by a System 3R, Transformer six-axis robot covers applications with transfer weight of 70–700 kg and radial reach up to 3,400 mm.

Ostini emphasizes that the way to get good utilization of the machine tool cell is to know how to use the robot to optimize your processes. "We suggest that the shop should start with palletizing the machines, manually putting pallets in and out. Once you're familiar with setting up the machine adding the robot and understanding the communications between the machine the robot is very simple." Then when the shop wants to go into multiple machines there is software available about how to optimize the automation and machine utilization."

To minimize non-productive time, System 3R created a software called Workshop Manager with modules that organize all the machines on the cell for optimization. Ostini explained, "For example, for optimization 'first machine available' is an option. What that means is if a machine goes idle the software can look into what is needed to fulfill the job and find a machine that is available for that job. The result is that the machine is never sitting there idle for hours, waiting for a process to be done."

Another way to optimize is through prioritization. The Workshop Manager program can look into the machine database of tooling and determine whether and where the tooling to do the

Automation can create highly productive cells by creating a process for detecting a pallet of a part or parts and moving it to machines throughout the process. For example, on one pallet a milling machine can carve out a mold which is transferred to a die sinker that puts rib inserts into the mold which then goes to a CMM to measure and make sure it's within standards for the job. While one milling machine is doing the mold work another milling machine can be making the graphite electrodes for the die sinker.

Pre-engineered Cells

According to Yarek Niedbala, vice president of sales for KUKA Robotics Canada, KUKA's North American partners such as Waybo have developed pre-engineered cells that overcome the difficulty of automating with robots from scratch. "Pre-engineered cells have been developed to North American standards that can be installed and up and running in a matter of hours," said Niedbala. "Training required is minimal because programs are parametric. These compact products have been developed with the small-batch, high-mix manufacturing requirements of small and medium-sized manufacturers in mind. Feed mechanisms and operation are very suitable for those applications."

Niedbala explained that a Waybo pre-engineered cell is essentially plug and play. The robot comes with two or three grippers to regrip a part and support OP10/OP20 operations. In addition to that are options for marking, deburring, measuring and cleaning, among others, that can be incorporated.

KUKA provides a wide range of robots starting with payloads of 4 kg and a 600 mm reach all the way up to 1,000 kg and a 3.9 meter reach. "But if a larger envelope is needed, we can place the robot on a linear rail and greatly extend its reach," he said. KUKA offers a range of mobile platforms with various payloads, some of which come with a robot on top called the KUKA Mobile Robot for machine linking that isn't limited by location of the machines.

However, moving robotic pre-engineered cells around the shop isn't always desirable. While the cell is being moved, the origination cell and the destination cell are typically not producing parts. Niedbala said that first-time users should figure out what machine is being used most frequently and then focus on automating that one machine first. "In one day, you can have the machine completely automated by simply adding one of Waybo's pre-engineered cells."

The next step would be to look for projects that can feed more work to that machine. "Once you have that machine at capacity then proceed to automate the next machines," Niedbala explained. "Many of our customers started with one robot automating one machine over one

machine and now they [have] multiple cells working in the shop, maxing out spindle time, which is highly desirable for expensive machine tools."

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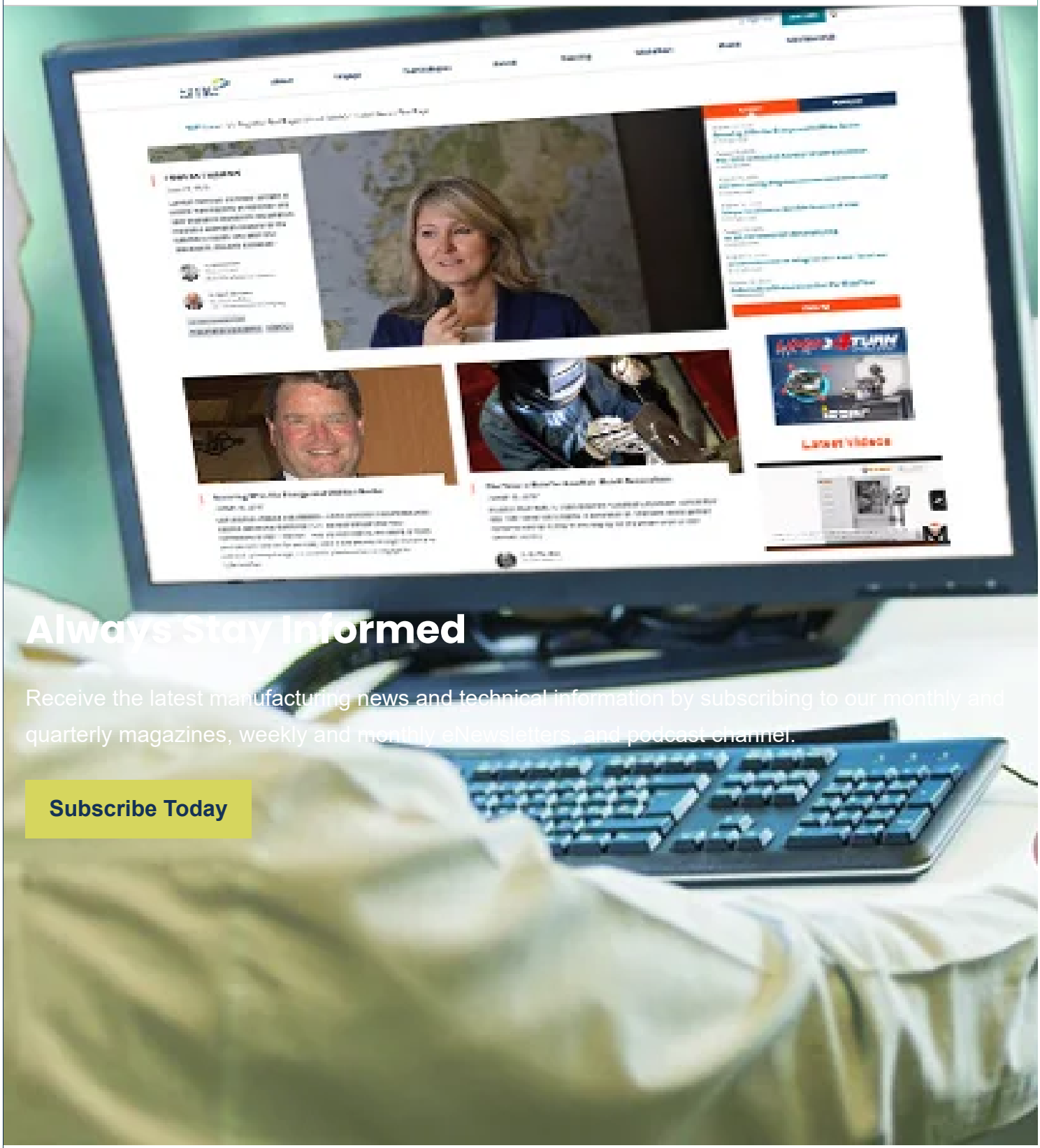

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