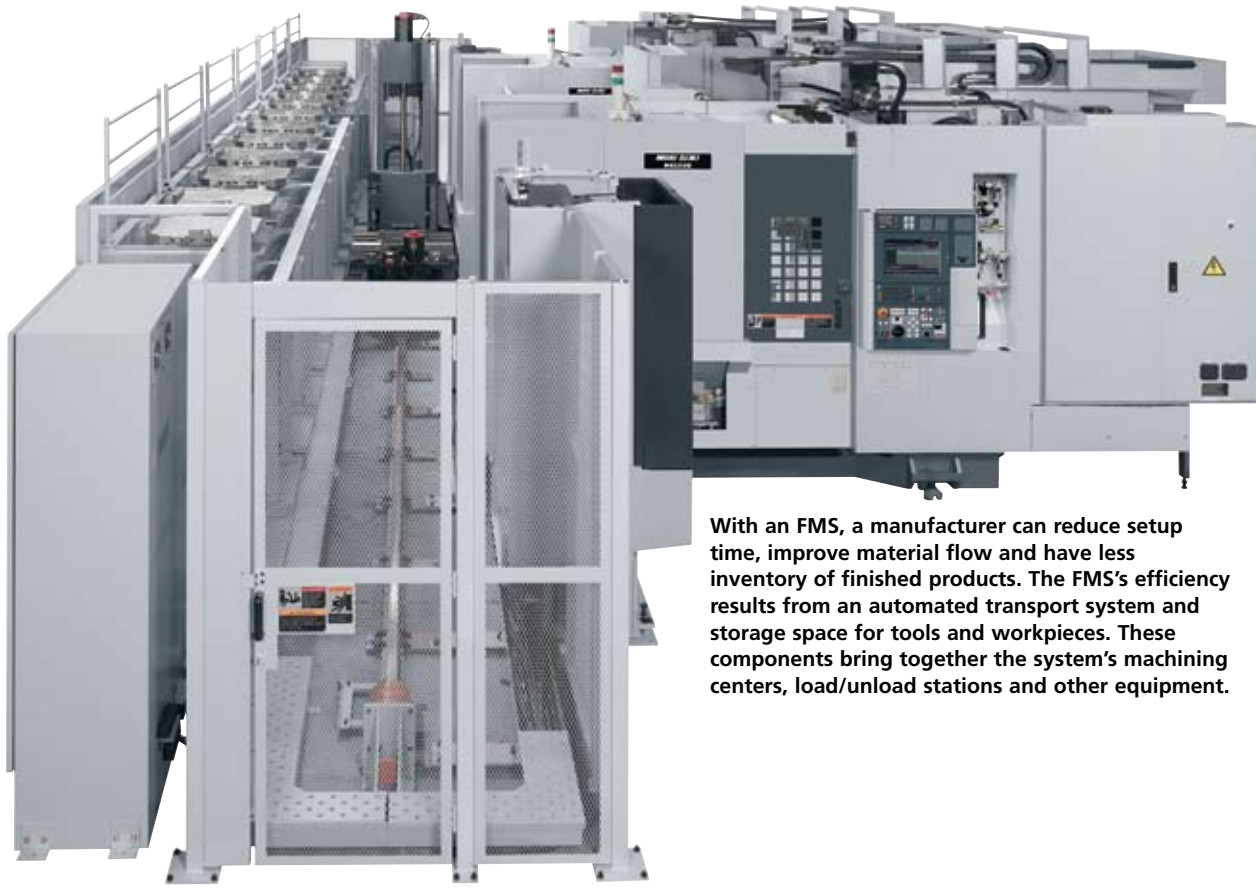
➤BY JOSEPH L. HAZELTON, SENIOR EDITOR



Mori Seiki USA

With an FMS, a manufacturer can reduce setup time, improve material flow and have less inventory of finished products. The FMS's efficiency results from an automated transport system and storage space for tools and workpieces. These components bring together the system's machining centers, load/unload stations and other equipment.

Flex Effects

What happens after you install a flexible manufacturing system?

Reduced setup time. Fewer machinists. Improved material flow. Less inventory of finished products.

The gains from a flexible manufacturing system are varied and significant. A manufacturer with a suitable workload could benefit noticeably by installing an FMS, which coordinates the work of machining centers, tool magazines, load/unload stations and an automated transport system.

But what other effects could an FMS have on a shop floor?

How would it affect first-article inspection? Would tool inventory need to be increased? How would the FMS affect the shop floor's organization? Would work responsibilities have to be redistributed among the employees?

Answers vary, depending on the manufacturer's part jobs, on how many jobs it wants processed via an FMS and on other factors. But the potential for change is considerable.

Less First-Article Inspection

With an FMS, manufacturers can save time on first-article inspection because it can be limited to the first time a part is run.

In a traditional CNC shop, before running a job, manufacturers often have to produce one part and send it to the inspection lab to verify via a coordinate measuring machine (CMM) or other equipment that the part conforms to specifications. This inspection also verifies the job's setup—that is, the cutting tools, workholding fixtures, CNC program and related equipment for machining the part.

However, the lab could be busy with

other work, so the operator might not get the part back for some time, maybe a day or more. Meanwhile, the job sits. With repeat jobs, these inspections are needed because setups are commonly disassembled between job runs.

"That's the traditional CNC side, even on a job that repeats," said Dale Poisel, project leader with Purakal Cylinders Inc., Eugene, Ore. The cylinder manufacturer's operation includes an FMS, which consists of a horizontal machining center, six pallets, a pallet-changing system, a load/unload station and a 180-tool magazine.

With an FMS, a repeat job's tools and fixtures aren't disassembled between runs. Instead, they and the CNC program are stored either in the FMS or where they can be easily retrieved for the FMS to use. As a result, the setup doesn't need to be requalified via first-article inspection for subsequent runs. Manufacturers don't have to idle a machine tool while waiting for the results of first-article inspection.

Consequently, later runs could be completed after in-process inspection of the first part's critical features using a spindle probe, said Bill Vejnovic, vice president of engineering for Toyoda Machinery USA, Arlington Heights, Ill.

Machine tool builder Haas Automation Inc., Oxnard, Calif., makes widespread use of FMSes, with 65 FMSes/pallet machines and a total of 938 pallets. As an example, its largest FMS features five HMCs and 140 pallets, along with pallet-storage and transport systems, six load/unload stations and five magazines, each able to hold 330-plus tools.

Haas and Purakal don't perform first-article inspection before a repeat job's subsequent runs. Instead, they use gages to perform in-process inspection of the parts.

Likewise, Carol Stream, Ill., component manufacturer Prince Industries Inc. doesn't perform first-article inspection on most of its parts' subsequent runs, opting instead for in-process inspection via gages and for post-process inspection via CMM.

However, Poisel said Purakal can avoid later first-articles because its FMS generally makes parts simple enough to avoid that inspection when a setup stays assembled.

A Job Run of One Part

Also, with setups remaining intact, an FMS can economically produce a single part during repeated runs.

"Now quantities of one are very realistic," said Marlow Knabach, vice president of marketing, Mori Seiki USA Inc., Rolling Meadows, Ill.

One-off production is possible because setup time is much reduced. An FMS is designed to minimize the setup time for a job that repeats. Ideally, the time would be confined to the initial setup before the first run and the replenishing of tools, raw materials, etc. In terms of tools, they would be stored inside an FMS's tool magazines, each of which can be made to store 60 to 500 tools.

"Once it's set up, it stays set up," said Mark Mohr, Mori Seiki's vice president. "You can amortize [setup time and cost] over several job runs."

There will still be setup time when replacing worn or broken tools. Prince Industries reduces that time, though, by qualifying a spare tool for each tooling assembly and keeping the spare in the FMS. Consequently, total setup time is reduced.

Who can use an FMS?

A manufacturer usually needs to produce parts in medium to high volumes to be a good candidate for using a flexible manufacturing system. The volumes must be produced through part orders that can be broken down into periodic runs consisting of small lots.

For example, Prince Industries Inc. runs two recurring jobs on its FMS in which each run consists of 500 parts. Also, each part's design needs to remain the same from run to run.

The small lots free up machines to manufacture many different parts in just-in-time quantities, said Bill Vejnovic, vice president of engineering for Toyoda Machinery USA. He added that as a rule of thumb, a cycle time for a pallet of parts should be at least 30 minutes.

"This can be accomplished either through individual part-cycle times or setting up the fixturing to take multiple short-cycle-time parts," he said.

Also, an FMS should be working for a certain number of hours for it to be justifiable. "Typically, you'd need to have three shifts of work," said Jim Morris, president of Automated Cells & Equipment Inc., Painted Post, N.Y. ACE manufactures automation equipment and designs flexible manufacturing systems.

The total amount of work can come from various combinations, like a shift's worth of manufacturing one part, a shift's worth of another part, a half-shift's worth of a third part and a half-shift's worth of a fourth.

—J. Hazelton

B&B Manufacturing

FMSes are best suited for small-lot repeat jobs. Preparing the jobs means creating part queues for the FMS. The queues are created at load/unload stations, placed in pallet storage racks—sometimes multiple-level racks—and moved to machining centers by a transport system, like the orange rail-guided vehicle pictured.

What is a flexible manufacturing system?

An FMS is an automated manufacturing system consisting of machine tools, a workhandling system and peripherals all linked via computers and designed to machine a variety of similar parts and to minimize production changeover time.

—J. Hazelton

Also, manufacturers can use the flexibility of one-off production to move their operations from batch processing to a more continuous flow of work, as sink and faucet manufacturer Moen Inc. did after installing an FMS in its Pine Grove, Pa., facility.

"You'll be able to switch from model to model much easier," said Michael Kautz, production manager at the Pine Grove site.

More Tooling Inventory?

With setups remaining intact between runs, a manufacturer could expect its tooling inventory to increase, but an increase isn't a certainty. Depending on its jobs, a manufacturer may be able to standardize some tools used for the family of parts slated for FMS processing.

"In some ways, it reduces our tooling inventory because you may have a common tool that's used on multiple jobs," said Mark Jones, president of part manufacturer and FMS user Clean Machine Inc., Salt Lake City.

Jones offered a ½" roughing endmill as an example, saying the tool could be used for six parts his company produces with its FMSes.

Likewise, Prince Industries uses the same tools for several jobs processed by its FMS. That system consists of four HMCs, 52 pallets, the pallet-transport system, three load/unload stations and four 135-tool magazines. The company also benefited from the concentration of tooling in the system. CNC supervisor Greg Lopuszynski said the FMS's tools were no longer spread over five or six machines.

Purakal Cylinders

Tombstones are a common part of many FMSes and allow for machining many of the same part or machining of multiple part numbers within one machine tool.

"We have less tools to use, [which means] less inventory," he said.

The effects on first-article inspection, one-off production and tooling inventory are practical and significant, but an FMS can have wider effects, too. It can transform how a shop floor is organized, how responsibilities are distributed and when volume production is done.

Shop-Floor Shuffle

Clean Machine's FMSes led it away from the old shop-floor model of one machine, one machine operator.

That model has drawbacks when trying to maximize productivity. Jones of Clean Machine gave an example. "This is Joe's machine. When Joe goes on vacation, his machine sits."

An FMS, though, can allow an operator to keep more machines working and keep them working continuously, increasing productivity. This means manufacturers may need to shuffle responsibilities. Clean Machine did so after installing its first FMS. Today, the company has a second FMS, which it's expanding from two 5-axis machine tools with 32 pallets and two 120-tool magazines to include a third 5-axis machine, another 32 pallets and

The following companies contributed to this report:

Automated Cells & Equipment Inc.
(607) 936-1341
www.autocells.com

Clean Machine Inc.
(801) 261-4206
www.cleanmach.com

Haas Automation Inc.
(800) 331-6746
www.haascnc.com

MAG Powertrain
(586) 566-2400
www.mag-powertrain.com

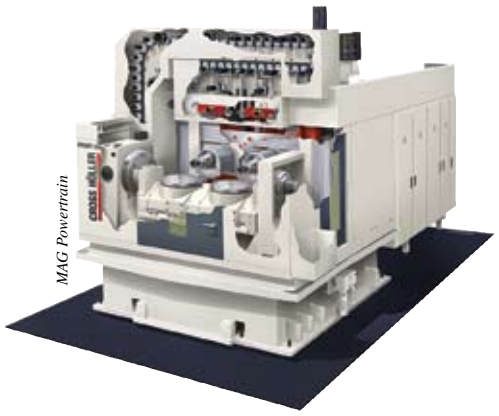
Moen Inc.
(800) BUY-MOEN
www.moen.com

Mori Seiki USA Inc.
(847) 593-5400
www.moriseiki.com

Prince Industries Inc.
(630) 588-0088
www.princeind.com

Purakal Cylinders Inc.
(541) 345-4199
www.purakal.com

Toyoda Machinery USA
(847) 253-0340
www.toyoda.com



MAG Powertrain

Tool magazines, similar to the one illustrated at top, can be made to store up to 500 tools, including already qualified spare tools, ready to replace worn or broken tools.

another 120-tool magazine. It's also ordered a third FMS.

Clean Machine developed four areas of responsibilities for its FMS operation: job programming, setup, production and deburring/finishing. Each responsibility is handled by a separate group of employees.

Programming includes writing needed CNC programs, developing inspection processes and establishing tooling and fixturing for a particular job. Setup consists of taking the programmers' output, readying the job for production and certifying via inspection that the first article conforms to specifications.

Naturally, production—done by machine operators—is the actual running of the job. The number of machines handled by individual operators can vary. "They might be running one machine," Jones said. "They might be running five machines." Those five could be two machining centers and three lathes, for example.

Also, an operator can leave the machines untended and take care of other work, returning before they process all the parts in their queues. He can leave the machines because flexible manufacturing systems include automated transport systems that move parts between machines and in and out of them.

The fourth area of responsibility is deburring/finishing, which consists of deburring, polishing, sandblasting, tumbling and other finishing operations. Clean Machine has deburring machines in its FMS, but it produces a number of parts that require manual deburring.

Haas Automation

An FMS can make first-article inspection a task for a recurring job's first run only. With the setup remaining intact between runs, later runs could require only in-process inspection. Here, an FMS operator performs a routine, in-process inspection on parts machined in an FMS.

Haas also has four areas of responsibility. Its technical support department consists of people who design a job's fixtures, create the CNC programs and set up the tooling. They also participate in production through a job's first-article inspection, and they troubleshoot production problems.

Operators run the jobs themselves. And they sometimes perform first-article inspection. Tool setters maintain setups in the FMSes, replacing worn or broken tools with new ones. Material handlers put raw material into the FMSes and remove finished parts.

Also, an FMS can concentrate volume production during part of the day, creating a new work rhythm for employees. In a traditional shop, volume production occurs throughout the workday. It's interspersed with the setting up of jobs, the manufacturing and inspection of first articles, and so on.

At Clean Machine, volume production occurs at night. The company uses the daytime for making prototypes, for one-off production, and for manufacturing and inspecting first articles, among other activities, a number of which prepare the FMS for its nighttime work.

Jones said the new work schedule has led to an in-house joke. "We lose money all day and make it up at night."

Prince Industries, meanwhile, split its shop floor in two when it obtained its FMS. The shop now has a traditional CNC side and an FMS side. The CNC side runs three 8-hour shifts, and the FMS two 10-hour shifts. The FMS also runs untended for 4 hours every day.

The FMS needs fewer operators than it would if its four machining centers were stand-alones.

During each manned shift, the FMS is run by two or three operators. Lopuszynski said in a CNC operation, each center would need one operator per shift for three shifts to process parts the entire day. Thus, four to six FMS operators take the place of 12 traditional CNC operators.

That reduction is one of an FMS's main benefits, along with reduced setup time, improved material flow and less inventory of finished products. To manufacturers, those effects may be worth the extra work of adjusting to an FMS's other possible effects. Also, a manufacturer's in-house benefits may create outside benefits for the company's customers.

At Prince Industries, Mark Paluch, vice president of sales and manufacturing, said, "We probably cut 2 weeks out of lead time, and that's out of a 6- to 8-week process." △

Planning for FMS expansion

Manufacturers should be mindful of the possibility of future expansion as they decide on the design and placement of a flexible manufacturing system. After all, more work can come, and it may involve processes and tooling that permit expansion of a current FMS rather than buying another one.

To keep expansion as an option, a manufacturer should include space in an FMS for additional machines or larger tool magazines, so it can make more of its current parts or additional amounts of new parts.

A parts manufacturer should also keep in mind that if it expands an FMS, the new equipment may be from the next generation of machine tools. So the manufacturer needs to ask the FMS supplier: Do you develop each generation of FMS equipment with standardized aspects so transport components, such as pallet changers, will be compatible with future generations?

For example, take a new machining center that accepts the same pallet size as an FMS's current machining centers. Will the new machine use the same pallet location and clamping system as the existing machines?

"With the ever-changing technology in horizontal machining centers, it is not uncommon for a machine model to be updated or replaced every few years," said Bill Vejnovic, vice president of engineering for Toyoda Machinery USA.

Another question for the supplier is: Are the FMS components modular?

Vejnovic cited pallet-storage stands and load/unload stations. If purchased as assembled modules, they could be bolted to the floor within the existing rail system, plugged in, enabled via the FMS controller and used for production. If the rail system wasn't long enough, rails and cabling could be added.

Manufacturers should consider inspection processes, too. They need to be sure they have enough coordinate measuring machine capacity and in-process gaging. "It's no good to be able to make the part without being able to inspect and control the process," said Ron Quaile, vice president of proposal and estimating for MAG Powertrain, a machine tool builder based in Sterling Heights, Mich.

An FMS needs to be placed on the shop floor in such a way that it can be expanded easily. If it's not positioned well, a manufacturer could have no room for another HMC or additional loading stations.

For example, if cylinder manufacturer Purakal's FMS was turned 90° clockwise, it couldn't be expanded. However, Purakal was mindful that it might want to expand the FMS later and placed it accordingly.

"It's like a house," said Dale Poisel, Purakal project leader. "It's location, location, location."

Also, a manufacturer can keep an FMS operating throughout most of an expansion. Prince Industries Inc. did.

The company expanded its FMS a year after it was installed. Originally, the system consisted of two HMCs, two load/unload stations and 26 pallets. Prince Industries decided to add two more HMCs, another load/unload station and 26 more pallets.

The expansion took 2 to 3 weeks, but the FMS was down only 2 days, during which the new machines, tested as stand-alones, were incorporated into the FMS. Prince Industries had organized the project so the system's two machines could run while the expansion was being done in the background.

—J. Hazelton