Five strategies for improving predictive maintenance and operational efficiency in flexible manufacturing

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Introduction

Flexibility is the ideal of today's manufacturing world. How can companies build exactly what consumers are looking for – and change course immediately in response to changing consumer needs – without sacrificing throughput and quality? For many manufacturers in nearly all industries, that is the ultimate question.

Flexible manufacturing originated in the computer numerical control (CNC) business, where manufacturers were trying to find a way to build a variety of customized products that were in demand. In order to build several differently sized wrenches on the same machine, for example, they would create a system to provide the correct raw material inputs for each wrench size and send each finished product to the proper location in the warehouse for shipping.

Today, flexible manufacturing has gone much farther than that. With the latest advances have come several new challenges due to these systems' complexity, which has repercussions for throughput, traceability, predictive maintenance and pretty much everything else. Fortunately, industrial automation technology is keeping pace with these challenges so that manufacturers can implement flexible production lines without becoming overwhelmed with their complexity.

This white paper will discuss the following strategies for getting the most out of a flexible manufacturing system:

- Designing for reusability of equipment and code
- Using an integrated software solution to construct a modular system
- Connecting stages of production with mobile robots
- Building an automated, real-time traceability system
- Using artificial intelligence to make predictive maintenance less complex

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Designing a reusable system with easy reconfiguration in mind

When high-mix, low-volume production is the norm, flexible manufacturing becomes a necessary challenge. However, there's no denying that flexibility poses a reduction in throughput when compared with production lines dedicated to a single product only. The changeovers from product to product always slow production down to some extent. The key is to design a system that maximizes the reuse of its components and keeps changeover time as short as possible.

Designing for reusability is crucial. If product changes require completely new equipment, this creates tremendous costs in downtime and the unnecessary use of plant space. Fortunately, both hardware and software can be designed for reuse so that manufacturers can flip back and forth between two or more versions of a product with relative ease. Automotive manufacturers, for example, embrace robotic solutions that allow them to run similar but slightly different vehicle programs – such as the base model and the sport version of a car – on the same equipment.

Robots are reusable, re-deployable assets that can change their programs on the fly. In particular, collaborative robots like Omron's TM Series Collaborative Robot make it easy to keep flexible lines moving because they are highly adaptable to changing environments and can be trained on new tasks with a safe and intuitive hand-guiding mechanism.

When paired with machine vision, robots become a complete flexible manufacturing solution that can efficiently respond to variations in products coming down the line. Omron's Anyfeeder part feeding system employs vision to present parts of all types to a robot, unlike other feeding equipment that must be redesigned for every new item. Robots themselves can have vision built in to enable flexible and precise vision-guided tasks, such as handling multiple different size and shape loads without needing to be reprogrammed for each one.

Another example of a highly flexible manufacturing solution is Omron's NC Integrated Controller. This controller adds the capability of executing G code within a standard automation machine, making it unnecessary to purchase a separate machine center to perform a single type of cutting or gluing task. The end user – as opposed to the machine designer – becomes empowered to design new cutting and gluing applications by loading additional G Code files. In addition, since the controller also has motion, vision and safety capabilities, there's no need to reprogram multiple machines to work together.

When it comes to reusing parts of a flexible manufacturing system, it's important not to forget the code that ties everything together. When manufacturers can reuse portions of the code, product changeovers become much easier. Omron's Sysmac Studio allows machine designers to do all of the programming – from motion control to sensor control to robotics – in a single environment, and it also facilitates code reuse.

Omron's TM series robots help companies produce a high mix and low volume of products, as well as harness the true potential of human resources.

Embracing modularity with a fully integrated software solution

Omron's Sysmac Studio helps significantly with another key flexible manufacturing strategy: building modular systems. OEMs and machine builders want to ensure that manufacturing machinery can be easily integrated, so they create smaller pieces that fit together like pieces of a puzzle. To facilitate modular manufacturing, the all-in-one software has many essential features such as easy simulation for reducing test time and project version management for collaborative design of modular software assets.

Sysmac Studio contains multiple function blocks and code libraries to facilitate code reuse and minimize commissioning time. As a true integrated development environment (IDE), Sysmac Studio ties all hardware pieces together which saves customers and field engineers significant time in designing, maintaining and troubleshooting flexible production lines.

True to the modular ideal, Sysmac Studio allows end users to choose whether they want to incorporate vision, robotics, safety and other function blocks without needing to employ multiple software packages to create a working solution. This add-on approach gives customers the flexibility they need to design a system that meets their specific needs and make quick and easy adjustments when necessary.

Omron's Sysmac Studio is one of the most full featured automation IDEs which handles complete machine automation including: information handling, visualization, networking, logic, motion, safety, vision, robotics and CNC and I/O.

Connecting the dots with mobile robots

The constant reconfiguring of modular systems means that paths through the production "line" – which no longer resembles a line at all – are constantly changing. This presents a major challenge. Parts of the production line are generally connected by conveyors, but when the paths keep changing, it becomes extremely unwieldy to use conveyors. For one thing, they're heavy and difficult to move. It's also tricky to change their lengths. Most importantly of all, conveyors can completely block an aisleway unless new production line configurations are planned out with extreme care and detail.

Fortunately, conveyors aren't the only option. Mobile robots like Omron's LD series provide a much more flexible means for connecting various production modules together without obstructing traffic throughout the plant. The LD Mobile Robots are self-navigating Autonomous Intelligent Vehicles (AIVs) that are designed to dynamically move material in challenging environments, including confined passageways and peopled locations. Their innovative software allows them to intelligently navigate around human workers and unplanned obstacles without requiring any facility modifications such as floor magnets or navigational beacons.

Mobile robots also help with adaptive warehouses in addition to production line adaptations. If there's a change in the warehouse destination of a finished product, the robots can be easily sent to a different location thanks to their intuitive and highly flexible software.

Mobile robots like Omron's LD series provide a much more flexible means for connecting various production modules together without obstructing traffic throughout the plant.

Mobile robots boost flexibility by transporting materials throughout the factory using an intelligent self-guiding mechanism.

Automating traceability to locate parts, products and equipment more quickly

Given just in time manufacturing requirements order build status must be visible. This means that the overall manufacturing system must make it easy to locate finished products and works-in-progress. Customers want to know how close items are to being shipped so that they can plan out their own operations more effectively.

The need to get answers in real time gets complicated by the fact that things are constantly moving around in a flexible manufacturing system. Equipment is being relocated, redeployed and reconnected constantly to accommodate new production needs, and in such an environment, it's almost impossible for humans to keep track of things manually. Manufacturers need to improve the visibility of their operations with a fully automated, real-time traceability system.

For flexible manufacturing, one of the most important aspects of traceability to automate is determining which product is being run at any given time. Flexibility has the potential to increase the occurrence of mistakes if key tasks are performed manually, but if the work-in-progress traceability is fully automated, a dozen or more different products can be run on the same line with a negligible error rate. On a food and beverage packaging line, for instance, information can be automatically registered into the system from the filler, which provides the data to the case packer and compares the date lot codes to ensure that they match. If the wrong product is going into a particular case, the system will sound an alert.

To create a robust, real-time traceability system, technologies that improve data flow are very important. Omron's NJ-SQL controller enhances traceability by allowing low-level machines to communicate work-in-progress location and status information to higher-level computers. Since the controller has client software for SQL databases, the average programmer can easily understand the software and reconfigure the database, as is often necessary for flexible production lines.

Omron's NJ101 SQL Client CPUs are designed to address basic industrial controller applications in a wide variety of industries including: automotive, semiconductor, infrastructure, and food and beverage packaging.

Overcoming the increased complexity of predictive maintenance with artificial intelligence

Flexible manufacturing systems are complex and tightly integrated, and this can make it difficult to predict when a particular piece of equipment is going to break down. For production lines dedicated to a single product, machine activity is much more consistent and predictions about breakdown are fairly straightforward. On a flexible production line, various equipment pieces all work together for high-performance, high-reliability operation, so it's typically a combination of many leading indicators that would correlate with a potential fault.

The sheer number of variables involved make it nearly impossible for humans to determine how each factor relates to the anomaly they want to detect. This is where the power of machine learning can save the day. Omron's unique AI Controller collects and transforms data within the machines it controls, analyzing them to baseline what constitutes normal behavior. When the data indicates the machine has done something abnormal, the controller can programmatically change operation to help save the product or equipment. This helps manufacturers reduce downtime while enjoying the benefits of flexible manufacturing.

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Omron's AI controller collects and analyzes machine data to determine what constitutes normal and abnormal machine behavior.

Summary

Flexible manufacturing is often necessary for keeping up with the demands of today's economy, but it comes with challenges. Throughput, predictive maintenance and other key measures of success can suffer if flexible production lines are not designed intelligently. Fortunately, manufacturers can employ several strategies to overcome these challenges, such as designing for reusability, constructing modular systems, connecting stages of production with mobile robots, automating traceability and harnessing the power of artificial intelligence to untangle complex predictive maintenance needs. These strategies and others will help minimize downtime and keep operations running smoothly while production needs change.

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