New challenges for process coordination in paper finishing and converting

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Process coordination can be optimized by adding process diagnostics that link the knowledge of the user and the knowledge contained in the control system.

At many paper finishing or converting operations today, automation technologies are often applied to isolated machines within the overall process, creating "islands of automation." These automation technologies include electronic generation of the shipping manifest through the use of bar codes, automatic storage and retrieval systems, and automated slitter positioning. Their use has made the operator in the finishing room more productive by minimizing the tasks that demand the operator's direct attention. The sequential nature of the finishing and converting process has, however, increased the number of potential bottlenecks.

Traditionally, an operator would visually detect bottlenecks and manually eliminate them. Because production rates have dramatically increased, however, this detection method has become impractical. As a result, new technologies have been sought to detect and correct bottlenecks in production. In addition, the operator's role has changed from that of reacting to crises to using knowledge of the system to coordinate the process. Today's control systems need to allow the operator to coordinate various "islands of automation," since these will remain common in many facilities for at least the next five years. In the future, however, islands of automation cannot survive. Let's examine what has driven us to this junction.

Three trends are evident:

- The marketplace is becoming more volatile for merchants.
- Product cost reductions require "just-in-time" deliveries and shipments.
- The marketplace has higher quality expectations.

First, the marketplace for paper is becoming extremely volatile. A paper merchant's customers, such as printers, graphics houses, publishers, and finishers, would like to be able to order paper on demand because of the widely varying preferences of their own customers. Merchants, however, do not want to commit to long delivery schedules from paper companies unless it affects their ability to operate their businesses. They try to balance the risk of lost business (as a result of being out-of-stock of a particular grade) against the cost of carrying inventory for raw materials that are unused. This decision leads to the product cost reduction through "just-in-time" delivery, the next trend.

"Just-in-time" delivery has been used as a method for reducing product costs, but it has not been a panacea. In fact, "just-in-time" delivery has been treated as a buyer-supplier problem. The problems could be summarized as a shifting of responsibility from buyer to supplier rather than a resolution.

The buyer tends to shift the burden of managing inventories to his suppliers to achieve just-in-time delivery, but suppliers continue to produce in large quantities and ship in small quantities to deliver their goods as they are needed. What is needed is a method whereby both the supplier's and the buyer's manufacturing process will lower production costs—for both parties (**Fig. 1**).

The last trend is the continually rising expectations for quality in the marketplace, which forces the paper companies to conform ever more closely to specifications. The solution should be directed to the manufacturing process rather than inspection techniques performed after the manufacturing is completed. Thus, the emphasis will be placed on preventing errors rather than on rejecting or correcting mistakes.

The manufacturing process must change to accommodate solutions to these changing trends. The "just-in-time" philosophy provides a solution for the volatile marketplace but does not contend with the role of the operator within the process. The role of the operator needs to change from one of reaction to one of making effective use of his own knowledge to achieve the coordination of islands of automation.

This shift in emphasis would lower production costs and could potentially be used to maintain higher quality expectations. The control system chosen is the crucial element in both of these solutions. Here, we will examine changes to the manufacturing process needed to shift from volume production of a few parts to production of greater variety. Next, we will examine the functions that the control system must perform for high-variety production. Finally, we will look at ways the control system can be used to provide

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operators with the information they need to react to and alleviate production bottlenecks.

High-variety production

The shift from high-volume production of a few products to high-variety production of many has placed greater emphasis on upfront design of the plant operations, especially to maintain low production volumes. Manufacturing and engineering groups must be involved with making various tradeoffs. When just a few products are being produced in high volume, the emphasis is on production rates and the operating costs of the machinery. The goal is to match equipment with process flows. When many products are being produced, however, the emphasis shifts to making better use of available machinery and raw materials.

You begin by determining how many products can be produced with a given set of individual machines. Second, you outline the potential paths that a product may take to achieve the lowest cost per unit. Third, you select a control system that is suitable for the production floor environment, where all of the process coordination can be accomplished without the aid of a millwide system. Finally, you tie into the order entry subsystem of the millwide system for overall mill coordination (**Fig. 2**). As this might suggest, a flexible operation does not materialize overnight—it must be planned and engineered into the logistics of manufacturing.

Flexible operations also place special requirements on the control system. When products are not made in a production line environment (high volume, few products), much more information about the final product (i.e., dimensions, guide settings, timing) must be passed along the production sequence. Each machine must have information throughout the entire production sequence to achieve close conformance to product specification and thereby meet the higher quality expectations of the marketplace.

First, controllers on the finishing floor must permit the operator to:

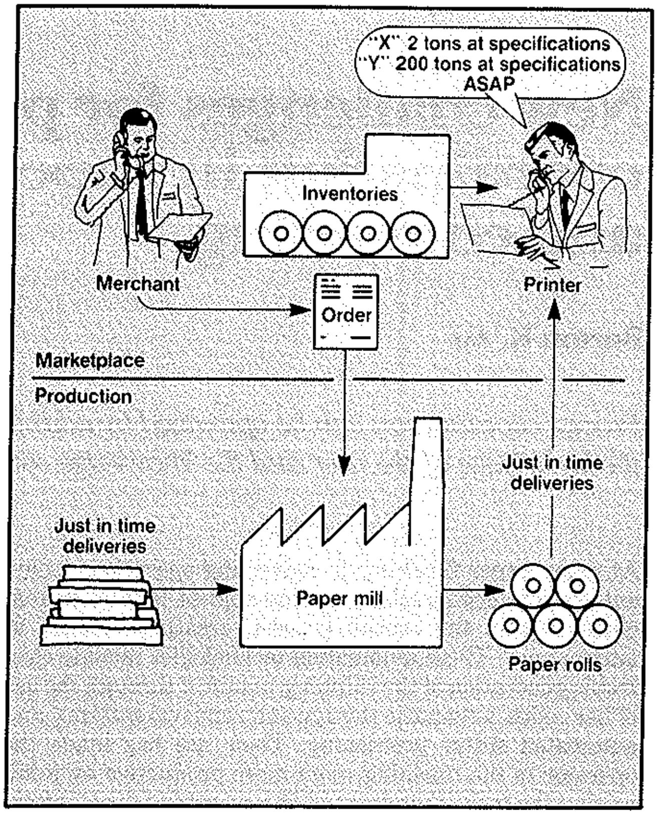
- Change programs for different products
- Account for the wear of tools such as slitters, knives, and dies
- Reduce mechanical setup time on the machines.

This capability increases the utilization of the machinery, thereby lowering product costs by producing a larger number of units. As a result, overhead becomes a smaller component of the cost of each unit.

Second, the controller must account for different paths taken by the material for processing, since information about the product to be made must be relayed to each machine involved. In addition, information related to the proper selection of raw material can also help minimize wasted material and increase profit margins. This function could be labeled as production processing. The question of "What is the best way to make it?" was resolved during the initial planning and engineering. Now the controller implements the solution to that question into the logistics of manufacturing.

Finally, the controller needs to keep track of where the production line is. Flexible operations have many end points rather than the single end point of a production line. As a result, the control system must allow the operator to

1. Just-in-time deliveries for both buyer and seller



determine the layout of the production line and identify the bottlenecks on the line.

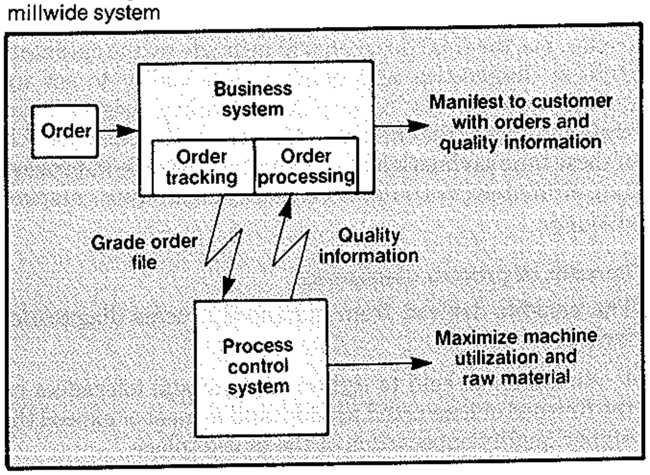
Increasing the utilization of machinery

In any attempt to increase machine utilization, we must be concerned with the ability of each piece of machinery to be used for the production of multiple products. The production rate of the machinery is becoming less important as production volumes are reduced. High production rates may generate long idle periods for machinery, since some machines are usually capable of producing far more than the line requires. This idle time, in turn, raises the cost of production as the overhead from this machinery is spread over fewer units of products.

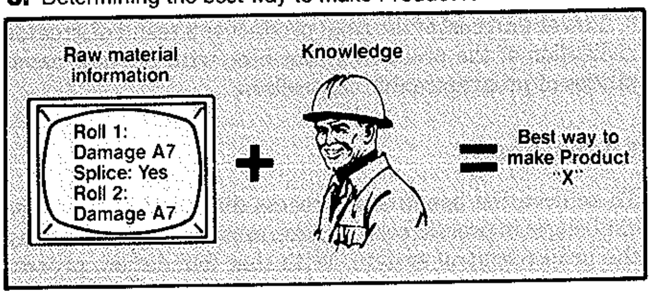
Today's programmable controllers, however, can coordinate multiple products on machine runs and will increasingly play a key role in the future. For example, programmable controllers can increase the utilization of machinery through programs that hold closer tolerances and decrease the setup time required when switching from one product to another.

In the past, programmable controllers were only involved with the sequencing and protection of machinery. Programs in those controllers did not account for tool wear or question whether the correct product was being produced. As a result, frequent tool changes were often needed, and these changes were often done only after unacceptable products had been produced. Today, the advanced-math analog capabilities, file structures, and other features found in programmable controllers make them capable of providing diagnostics that account for tool wear. For example, when on-line sharpening is performed, the penetration depth must be readjusted after each sharpening. The program-

2. Achieving mill coordination by tying order entry into the millwide system



3. Determining the best way to make Product X



mable controller may be used to recalculate the new position of the knife to reach the required penetration depth. Machine utilization is increased by lengthening the time between knife changeouts.

Further improvements in machine productivity may come from decreases in the setup time as a result of automatic adjustments. For example, automatic slitter positioning has the most direct payback of all the slitter adjustments because of its ability to handle damaged rolls. Defects on damaged rolls, such as hot areas, areas damaged by foreign material, thread or "dandy" marks, and howling, must be removed from the salable portion of the roll.* In the past, the slitters were manually adjusted for each roll. Mechanical setup time was lengthy, and machine productivity was low. Machine utilization is increased by eliminating the substantial amount of setup time required to reposition the slitters to remove the damaged area.

Thus, in obtaining the maximum use of machinery on a high-variety production line, we must be concerned with:

- The repetition of machine actions
- The maintenance of specified tolerances
- The minimization of setup time.

The programmable controller's file structure format allows these aspects of control to be combined in various ways. Each file centers on a separate aspect. One file is created for machine actions, another file contains specification programs that compensate for tool wear, and the last file might contain mechanical adjustments required for each product. Sets of files are matched to each product and stored in the programmable controller.

The control system is an important means for achieving and increasing machinery utilization. Ultimately, improvements in the utilization rate of individual machines will reduce the unit cost of the product as more products are produced. These requirements are the first of the challenges in process coordination for the finishing and converting department.

Making better use of raw materials

Production processing involves a good deal more than producing the product to fill an order. Raw materials must be optimized. Those of us who had woodworking in high school can recall that the rule was to use the raw material, or lumber, that was closest in dimension to what was required by the various tasks. You wouldn't want to cut a 1 ft section off a 1.5 ft piece of lumber because you would have 0.5 ft of waste. You would probably take it from a 10 ft piece, because you knew there was a high probability that another job would require a piece of board measuring 9 ft or less. Similarly, it is possible to avoid selecting a damaged roll of paper from inventory if information on the defects and their locations is available in the form of electronic manifests. Information about the raw material and the product should be made available to the operator by the control system using logically mounted displays.

This information is important to the machine as well. The control system must have the ability to send the relevant information to the affected machine. A peer-to-peer communication network is quickly becoming a necessity.

Production processing also answers the question "What is the best way to make Product X?" Illustrated in **Fig. 3**, this is the second of the challenges in process coordination for the finishing and converting department. In many cases, a microcomputer running a routine, generally written in a computer language like BASIC, accesses production information available in the programmable controller or in multiple programmable controllers. This information might include data concerning the size of the job, how much material is left on the roll, what steps are required by the next process, etc. The program must optimize the available raw materials to the production specifications. This method provides the least expensive solution to be selected from the raw material located in inventory. The benefits are the achievement of "just-in-time" operation and reduction of inventory carrying costs.

Gaining better logistical control

Traditionally, the manufacturing approach emphasized a production layout based on single lines of production. The advantages of a single line include both optimized utilization and the knowledge that the finished product or work-in-process could be located at the end of the line. The change from a high-volume production of a few products to high-variety production of many products has resulted in many different end points in the process. Now it is necessary to know where the product is in the production layout so that you can fetch it manually or automatically when it is completed or so that you can clear a jammed production line.

The quick resolution of bottlenecks or jams in a multiple layout production line is the third challenge in process coordination for the finishing and converting department.

Future logistics systems will use a CRT at the plant floor to provide information relevant for a single operator to

*Karis, A., Pulp & Paper 61(2): 58, 1987.

resolve bottlenecks. Today, a majority of converters and finishers have to deal with display panels that only alert the operator to machinery problems rather than indicating where the product is in the production process. Information distribution and quick action on the floor will be a key factor in lowering product cost and in identifying problem areas in production.

Process coordination

Ideally, the production process should be coordinated to allow the seller to deliver quickly to the buyers without having to keep a tremendous inventory of finished product. In process coordination, the attempt is to match the needs and requirements of the buyer to the seller and to provide a solution for "just-in-time" delivery. In practice, successful process coordination requires that management and production personnel have the knowledge to make the correct decisions. Process coordination requires a strong base from which to build.

Coordination through built-in diagnostics

Process coordination begins with the machinery. Machines must have more "intelligence" to enable the operator to be more productive. This "intelligence" includes the built-in diagnostics that are the key to lowering product cost. Machine diagnostics can assist with recalibration and can decrease setup time. These diagnostics inform the operator, for instance, that the machine should shut down because the slitter knife has decreased in diameter below the acceptable operating limits.

Critical dimensions such as these are constantly being monitored and recalibrated by the programmable controller, but the final decision will be made by the operator. Built-in diagnostics also enhance the ability to set up quickly and thereby reduce the downtime arising from knife changes or die changes or from a product change. All of these time savings lead to a reduction in work-in-process and, ultimately, to a quicker response to the buyer's market changes.

Benefits of process diagnostics

The benefits derived from enhanced process diagnostics include:

1. An ability to hold to tighter dimensional tolerances on the finished or converted product and to meet or exceed the higher quality expectation of the marketplace
2. Minimization of downtime caused by recalibration and setup. The benefit is the increased utilization of machinery and potentially high throughput, or faster turn-around.
3. Lower unit cost of the final product as a result of greater utilization of the production machine with the new capabilities of programmable controllers.

Conclusions

To achieve the benefits of process diagnostics, the three challenges in process coordination must be met by selecting the proper control system. With that foundation, process diagnostics link the knowledge of the operator with the data contained within the programmable controller system. In addition, management can add its contribution to this knowledge database to achieve lower unit costs for the final product.

The converting machine or finishing machine supplier can help lower your unit costs by satisfying the need to switch from high-volume production of a few products to high-variety production. The control system helps in increasing machine utilization, in matching raw materials to finished products, and in identifying problem areas to the operator and to management.

Thus, process coordination can be optimized by adding process diagnostics that link the knowledge of the user and the knowledge contained in the control system.

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