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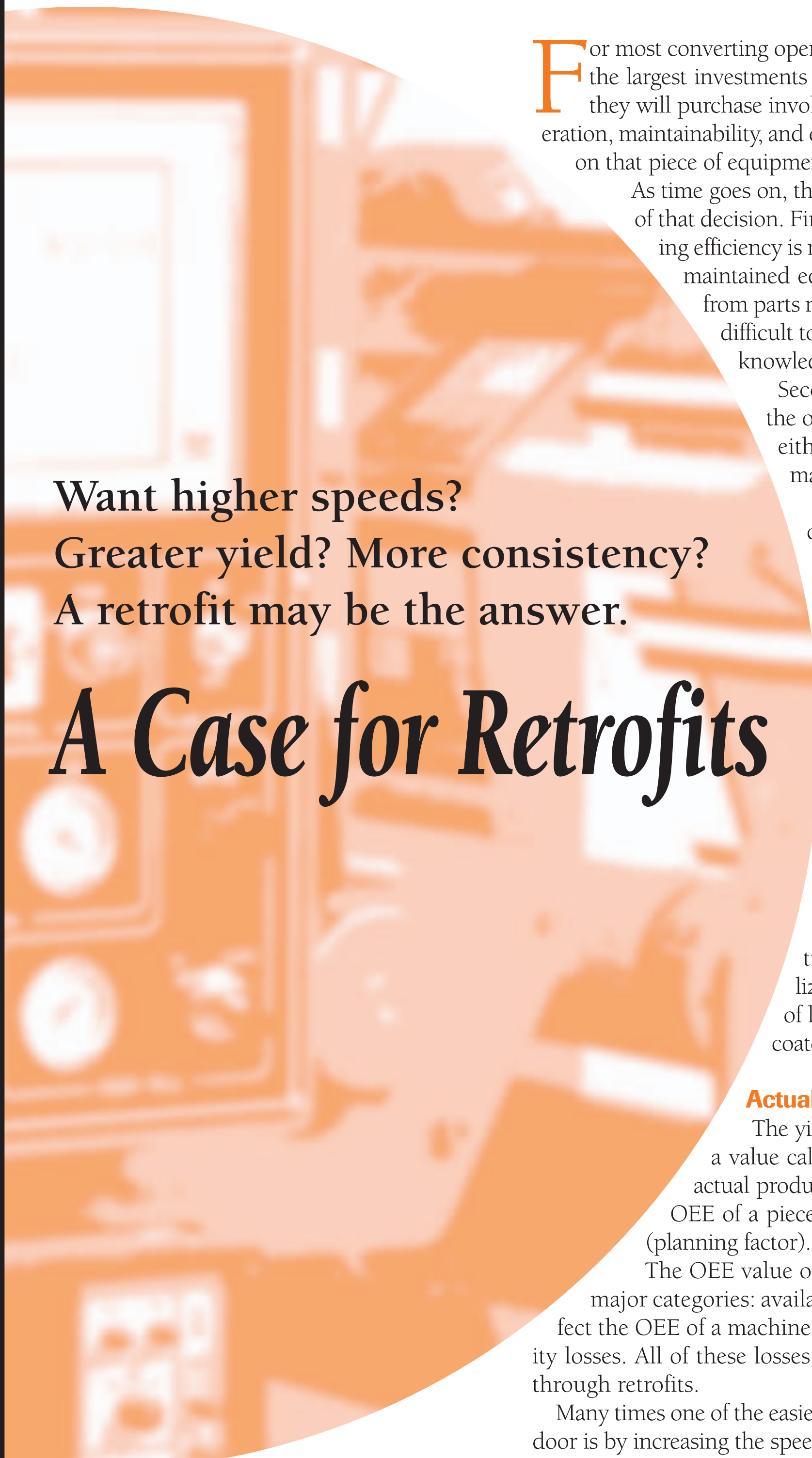


Want higher speeds? Greater yield? More consistency? A retrofit may be the answer.

A Case for Retrofits

For most converting operations, the capital investments in machinery will be the largest investments they will make. The decision on which equipment they will purchase involves assumptions on the yield, flexibility, ease of operation, maintainability, and other factors that will affect the return on investment on that piece of equipment.

As time goes on, three things happen that challenge the original model of that decision. First, as the equipment gets older, typically the operating efficiency is more difficult to sustain at a high level, even on well-maintained equipment. This could be due to reasons that range from parts mechanically wearing to electronics failing and being difficult to replace, to personnel changes that remove the core knowledge of that piece of equipment.

Second, more than likely the potential profitability of the original products being run has diminished per unit, either through competition or by normal market demands.

Finally, original equipment manufacturers (OEMs) continue to improve their equipment, primarily on the electronics side, increasing its value to end-users. This leaves the converter with an under-performing piece of equipment, and the options of living with lower profitability, investing in a new piece of capital equipment, or retrofitting the older equipment to bring it up to today's standards.

The yield of many converting process lines can be improved through the use of advanced process controls. Technology readily available with digital drives, programmable logic controllers (PLCs), and SCADA (Supervisory Control And Data Acquisition) software packages can be applied to older machines with significant positive results.

This article provides details of how advanced controls can be applied to improve the throughput, utilization, performance, reliability, and information flow of large converting process lines, including metallizers, coaters, and laminators.

Actual Productivity

The yield of a machine can be quantitatively measured by a value called OEE, or Overall Equipment Effectiveness. The actual productivity of a machine, Pr, is a value derived from the OEE of a piece of equipment times the planned production time (planning factor).

The OEE value of the equipment quantifies productivity into three major categories: availability, performance, and quality. The losses that affect the OEE of a machine are unplanned downtime, speed losses, and quality losses. All of these losses are candidates for investigation of improvements through retrofits.

Many times one of the easiest ways to allow more product to be shipped out the door is by increasing the speed at which the equipment is run.

This typically is feasible through improvements made in the process, through the chemistry, rheology, or other technological improvements that weren't there when the machine was installed initially. In the chart of machine productivity (***Figure 1***), a machine speed increase changes the value of the theoretical productivity = 100%.

Most typical industrial machinery usually can be increased up to 33% using the existing rolls and drive train. An engineering evaluation needs to be conducted to determine new motor sizes and drive outputs. In some cases the mechanical system is not up to the stress placed by a speed increase, and you need to consider carefully whether this action is appropriate.

Figure 1

Machine Productivity

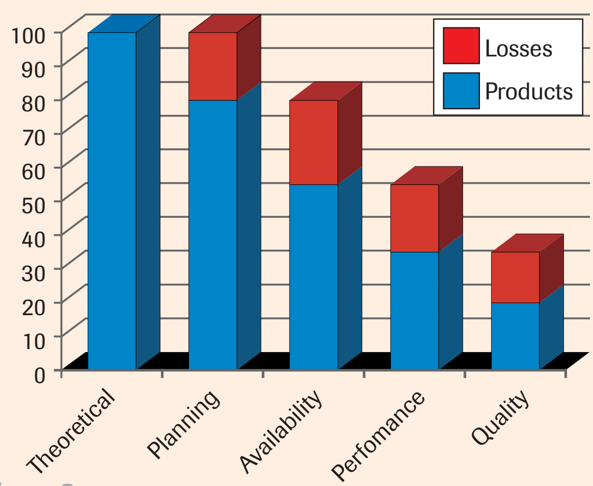
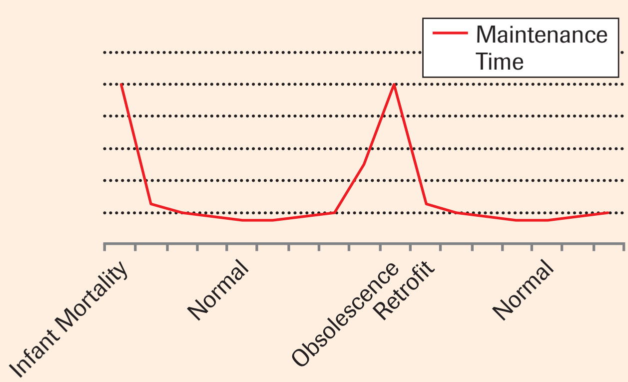


Figure 2

Control System Life Cycle



Unplanned Downtime

After looking at the total amount of product a piece of equipment can produce, the next logical step is to look at the reasons a piece of equipment is down and not running when planned to run.

This can fall into two categories: (a) equipment failures; (b) setup and adjustments. Here, too, modifications often can be made to existing equipment that can help reduce the amount of losses that affect the availability of a machine.

Equipment Failure or Breakdown

As equipment gets older, maintenance requirements increase. With most of the mechanical components, this is not an issue, as a majority of the components are mature technology that does not rapidly change, meaning spare parts are readily available. This is not the case with the electronics on a machine, however.

While many sensors (limit switches, thermocouples, etc.) are the same mature technology, other more advanced sensors (ultrasonic sensors, beta gauges, etc.) are not; they are evolving rapidly. The latter is true of most controllers, such as PLCs and drives.

Many manufacturers of AC drive technology, for example, tend to release a new model every 18 months as the technology becomes available. Although this new technology gives its users capabilities and features not possible before, it also creates a challenge in maintaining the equipment.

In the life cycle of a piece of equipment (see **Figure 2**), there comes a point when the amount of maintenance of the equipment electronics becomes disproportionate due to obsolescence and the lack of availability of spare parts.

Setups and Adjustments

Setups and adjustments are needed to prepare the machine for whatever product is being run. This time period, especially if there is a lot of product change, can be significant. This category also covers machinery calibration. Again, this can be quite significant on older analog drive and control systems that drift compared to newer digital systems.

The set-up and adjustment time can be reduced significantly through the use of automation that can be retrofitted to many older lines. Controllers such as digital drives, tension controllers, and temperature controllers, besides requiring less calibration due to drifting issues, also will be able to handle a higher range of products.

SCADA systems, using a recipe structure, can set up a line completely from a main desk. The recipe eliminates the time required for a point-by-point setup. Also, due to the accuracy of a computer-controlled recipe setup, the line will not be as likely to generate waste as a result of improper setpoints.

Through automation, changeover time also can be reduced drastically. Changing the machine configuration for using multiple web paths, for instance, can be automated easily, further reducing losses and increasing the availability of the machine.

Not Enough Speed

Speed losses categorize any situation in which the machine is not running at its optimal speed.

Sometimes this is due to the process being run (a heavy coatweight without enough dryer capacity to run full speed). Other times it is caused by equipment deficiencies that do not allow the process to run full speed (slowing down to make a splice).

Although the first situation is usually known at the time of equipment purchase and is a conscious decision, the latter situation typically is due to incorrect machine operation. Both situations merit examination for improvement.

In the first situation, it is worth reassessment of the original economics for not putting the proper equipment into place during the initial purchase. Are the assumptions still valid? Has the cost of the equipment decreased? Is there any new technology that can be used to accomplish the same thing? You may find that assumptions that went into the original decision-making process are no longer valid, making it economically worthwhile to retrofit additional equipment to achieve maximum speed.

In the latter situation, something that was working when the machine was originally commissioned may no longer be functioning. Are there parts broken or misadjusted? Are the procedures being followed correctly? Was the original system not robust enough with enough latitude? In any of these cases, the situation is causing lost potential revenue and needs to be rectified.

Quality Losses

Quality losses occur when the product coming off the machine is not deemed salable. Quality losses can be generated during startup, while the machine is being brought up to speed and adjusted, or can be rejected product that occurs during normal production.

Losses During Startup

Losses during startup typically are attributed to the system ramp-up process in which the machine parameters come into the specifications required by the product being run. Unless all of the process parameters are within their tolerance, scrap material is being produced. Such typical parameters are ovens coming up to temperature, the line speed ramping up, and tensions stabilizing after the ramp-up.

The quicker these parameters can be bought into their tolerance band, the less scrap will be produced. Here, retrofitting a machine with an updated control system can have very positive results. Following are some examples:

- **Increased Drive Stability.** Advanced DC and AC drives are capable of performing the necessary calculations for outer loop control digitally at the power converter level. This provides the line with a more reactive system that can accommodate a wider range of substrates and dynamic conditions. This will allow for the machine to ramp up faster and stay in control better than a drive system that is stable.
- **Other Digital Controls.** The use of digital controllers for temperature and pressure loops will enhance the reliability and predictability of a system greatly. It also will have wider latitude to handle many substrates without changing parameters, and it will allow the system to stabilize faster due to the many advanced control algorithms available.

Rejects During Production

During production, scrap sometimes is produced predictably—as a splice going through a machine, and sometimes unpredictably—when a process parameter goes out of specification or the web breaks. Again, each of these situations can be handled effectively by retrofitting the equipment with the proper systems.

To help the predictable scrap situation, it is important to minimize both the occurrence and the effect of the disturbance. Taking the example of a splice at the unwind, mounting larger rolls and leaving less material on the core both would have a positive impact on reducing the occurrence of splicing.

The former typically would involve at least a drive upgrade, if not a new unwind to handle the larger rolls, while the latter would involve retrofitting the unwind with controls to minimize core scrap. Such a system also will control the tail length of the splice, minimizing the possibility a long tail will catch somewhere while being transported through the process. This reduces the chance of web breaks, reducing the likelihood of unpredictable scrap.

Many times, unpredictable scrap is not as apparent as a web break. It may be more like a dryer temperature that is out of spec, causing a curing problem that is not found until the quality control lab checks the roll, perhaps hours later, or worse, when a customer has an issue with the product.

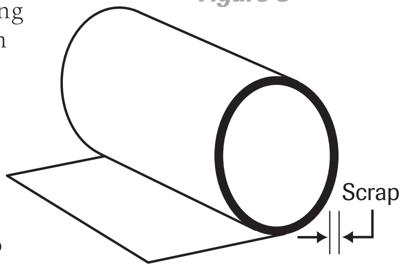
To reduce this type of scrap, an aggressive program must be put into place to monitor the parameters of the equipment constantly. There are several levels on which this can be done, but all involve retrofitting the equipment with proper sensors and control system to monitor the process parameters. A few of the levels are presented below.

- **Fault Detection.** Using the advanced fault-finding capabilities that are part of most modern controllers, the uptime of a line can be extended. Faults, such as an exhaust fan tripping, are identified more quickly. In addition, parts can be replaced before the fault becomes a critical "show stopper," enabling the line to run longer.
- **Correct Process Setpoints.** For the product to run correctly, the machine parameters must be set to the proper value for the product being run. Although this seems like an obvious statement, actually it is difficult to achieve consistently since there may be dozens, if not hundreds, of parameters on the machine that must be set. If they are set manually, there is a good probability of human error.

There is also a level of subjectivity introduced in which one operator or shift likes to run the machine one way, another operator another way. This leads to different quality products from shift to shift.

A solution is to use a computerized recipe setup in which machine parameters are downloaded to the machine correctly and consistently, providing for uniform product quality settings.

Figure 3



Savings, Savings

Upgrading your equipment can lead to many types of savings:

- **Web Savings.** A customer that uses flying splice equipment understands the value of minimizing material left on a core after splice-over. A process control upgrade to implement auto splice as a function of diameter can minimize the wasted web drastically (see **Figure 3**).
- **Coating Savings.** By adding a coating thickness gauge/monitor to the process

control system, the process line then can be operated in closed-loop fashion. This can reduce the amount of required coating applied to the web to produce in-spec material initially, as well as to keep the product within specifications.

- **Labor Savings.** As a result of automation, the process lines are capable of features that reduce the need for certain functions that have traditionally required operator involvement. For example auto splice and alarms generated from the main SCADA computer reduce the need for operators to stand by the line monitoring its status.

Other benefits include:

- **Unwind Splicing Reliability.** By converting the splice control from a traditional lap splicer to a predictive unit, the tail length can be minimized. This provides a better splice that can be conveyed through the machine more reliably.
- **Unwind/Rewind Diameter Control.** One of the most troublesome components in a legacy drive system is the means of diameter calculation. This leads to instabilities that increase the occurrence of web breaks. A new system using a digital drive can perform this calculation at the drive level, eliminating the problems associated with poor diameter calculation.
- **Automatic Features.** Once the entire line is under the control of a single system, higher automation features become possible; e.g.: automatic nip jumping to allow splices to pass through the line, or sequential line thread with tension loop, enabling the line to produce increased yield.

Candidates for Yield Improvements

When considering a process controls-based improvement to meet the needs outlined above, keep in mind certain lines are more suited to these improvements than others. Look for the following characteristics:

- The line's age should not be so old that it becomes cost-prohibitive to try to create the necessary drive train and instrumentation required for modern controls.
- The line needs higher performance for reasons of process parameters, production, quality, or other critical business purpose.
- A final candidate is a newer line that does not meet the initial expectations of the specification. Or, it could be a line in which the technology of the product has changed. In some cases a process controls-based yield improvement can solve the problem.

Who to Call

When making the decision to proceed on a project for process controls-based yield improvements, selecting your partners to perform the work becomes important.

To develop the specification for the improvement, you should use an engineer or consultant with expertise in the converting industry. The specification phase will help identify and determine the business needs for the improvement and help define the scope and expectations.

Once you have a specification for the actual work to be done, your best partner is either a systems integrator that specializes in the converting industry or, if the line requires major mechanical work, a process equipment OEM that has additional mechanical expertise and process capabilities and will manage the controls portion. In either case the project can and should be handled on a turnkey basis to prevent any oversight resulting in budget problems.

What to Improve

Of all the possible areas for improving yield through process controls on existing equipment, typically a few will return the most yield for the investment.

Drives are usually the first segment users will improve for increased throughput and higher reliability. Modern digital drives are relatively easy to retrofit to existing machinery, granted the mechanical equipment can handle it.

PLCs are great for retrofitting old, high-maintenance relay panels and early proprietary controllers. They can replace and integrate many single-controller functions, such as temperature controllers, into one unit.

Operator panels also are a prime rebuild improvement, increasing reliability and reducing operator error. An ergonomically laid out operator panel will not only make the line run more intuitively, but it often will regain a great deal of valuable factory real estate!

A SCADA system in most retrofits doesn't actually replace anything, but it can be an add-on component that improves process understanding. Also, it can be an invaluable tool for averting production of scrap and for troubleshooting problems.

When *Not* to Improve

It is not cost-effective to perform controls rebuilds on all lines. There are some general guidelines to consider that may deter a user from a potential process controls rebuild project.

For example, if the line is too old, it may not have the necessary drive train or instrumentation on it to benefit from a controls upgrade. Adding the necessary equipment would make the project prohibitively expensive.

If the process, such as the coating or curing methods, is antiquated, it probably is not worth sinking more money into that line. Typically, investing in the new process is a sounder long-term strategy.

In conclusion, retrofitting the process control system of an existing line can create enough yield improvements to minimize the need for a new line, *if* you study the problems carefully and are certain a retrofit is warranted. PFFC