Making Change --A Practitioner's Guide to Process Automation and Information Management

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ABSTRACT

For most industries, automating the process has become key to survival. Process automation not only improves productivity and efficiencies, but it also provides management with information about the products, how they are produced, and the people who are responsible for their production. Via computer technology this *production* information is often-times available on a *real-time* basis to assist all levels of management in better understanding the production processes -- at levels which were once difficult to attain. It is the objective of this paper to review some of the issues which might influence the decision of a company to proceed with automation at the plant floor. A Case Study will be given to explain the efforts of Avondale's Integrated Manufacturing Systems (AIMS) group as it supports the decision-making and implementation phases in a major textile company's process automation effort.

INTRODUCTION

During the past decade, textile companies have accomplished a certain level of *process automation* by replacing older equipment with newer machines which are micro-processor-based via capitalization. These *islands* of automation have positively impacted quality, productivity, and overall machine efficiency. Like most companies, textiles recognize that in order to continually compete in the *global market-place*, they must continue to produce high quality products cost-effectively. And in order to accomplish marketing objectives which have *been extended from the United States to the world* these companies are beginning to utilize *computer technology* to *extend* the automation effort from the machine level to the plant floor to the entire company. *Process control and process automation* are being achieved.

The automation effort that has been extended to every level of the process (and every related job) ensures that productivity is enhanced and that every job is performed more efficiently and cost-effectively. The typical levels of automation which once resulted in islands of automation were not integrated with corporate or other manufacturing systems, causing the information about the process to *only* be available locally at the machine and plant levels. Integration of production systems with other systems has provided a more *pro-active* management environment -- resulting in the ability to better *control* the process. In addition, this integration has fostered a more *real-time* understanding of the *state of a facility (and ultimately the company)* by making the information from the plant floor machines accessible by the necessary levels of management and support services throughout the company.

Today's successful *process automation* effort addresses machine, labor, and resource utilization issues as well as those issues related to data accuracy and data flow (availability) in the production environment. Companies are utilizing the *process automation* effort to provide an *integrated manufacturing* environment. The basis of this effort has revolved around a recognition that *process automation*, when effectively implemented, can reduce the cost of operations, improve quality, and provide information about the process such that *proactive management* is achieved. *Today's process automation effort is being*

accomplished using as many of a company's existing support service resources as is feasible such that the overall cost of installation, implementation, and long-term ownership of systems for process automation is reduced. ***The utilization of internal and external resources in a partnering environment is assisting in making the decision to automate an integral part of the manufacturing process by inherently reducing the cost of system support and services.***

In the discussion that follows, some of the issues which must be addressed relative to process automation will be briefly discussed. The discussion will be followed by a Case Study which reviews the approach being used by Avondale Mills as it utilizes its *AIMS* group in the development of *integrated* systems for *process automation and process control*.

WHY AUTOMATE?

Developing the Rationale

As previously stated, there are many reasons why companies choose to automate. Let's review some of the more common reasons briefly:

- Reduced Labor Costs
- Reduced Energy Costs
- Reduced Raw Material Costs
- Improved Quality
- Reduced Waste
- Reduced Reworks
- Reduced Capital Equipment and Engineering Costs

The properly implemented process automation project will provide significant benefits in one or more of the above-listed areas. In practice the process automation projects which are most easily approved include justification or ROI via achievement of cost-*savings* associated with one or more of the objectives in this list. But what about the process automation projects which have benefits which are not immediately quantifiable? How are they justified?

Automating the Information Flow

For example, a clerk must schedule goods from one step of the process to the next. Currently the goods are scheduled via a piece of hand-written paper which is carried to each location. At each location, the information from the paper is transposed to another piece of paper which is kept in a file cabinet in that department; the production information relative to this next step of the process is added to the paper and carried to the next department. This process is repeated until all of the process steps have been completed and production data has been gathered for each process step. The clerk enters information about the end-product (at each processing step) into a data entry screen provided on the traditional Information Systems (IS) computer which accumulates production totals by product, by shift in a summary report on some *batch* basis. While information about the products produced is available in each department, the overall product performance data -- the quality, production rates, efficiencies, problems, etc. -- is only available *after* the process step is completed. Furthermore, folks outside of the production area must wait until the information is available via a batch reporting process from the IS department -- a process which may take hours or days depending on reporting priority.

This entire *process* could be *automated* by developing a computerized on-line *production* reporting/scheduling system. The clerk would be able to queue up the products which are scheduled to be run in each step of the process via a computer terminal (CRT) or personal computer (PC) at a desk. At each step of the process, operations personnel would be provided with a CRT or data entry station with a scanner for production data input. Production data would be entered into the system *either by the operator*

via this data entry station or automatically via computer to machine communications (if the machinery is equipped with a microprocessor which can be accessed by the computer). Software would be written to automatically capture, accumulate, report, and store this information on an *event driven* basis -- either *real-time* or *near-real-time* -- so that information about the product is readily available at each step of the process. The *production* computer system's software would include validity checks to *improve data accuracy* and reduce errors in the data entry processes for both the floor operator and the clerk.

When the operator tells the system that this step of the process has been completed, the system would *automatically* schedule the next product to be run at this process step from the previously defined queue. The system *could be extended* to include the *automatic* download of machine setup parameters by product to further reduce the data entry process. A *bar-coded ticket* or radio frequency identification (*RFID*) could be automatically printed at the completion of each process step as a "*tag*" for tracking product throughout the production processes. And this automated process of production data collection and job queuing could be utilized at each phase of the process until end-product manufacture is complete.

The clerk who once spent hours on the plant floor chasing production data that is already *old* when it is retrieved would be able to constantly monitor the status of the products at any given process step via a CRT/PC. He/she would remain at a desk -- scheduling many different products on different machines via this production system. He/she would also maintain constant communications with department personnel so that adjustments in the schedule due to equipment malfunctions, operators, etc. , are accurately entered into the system to reflect *real-time* processing problems at the plant floor. *This clerk's job would not be eliminated*; however, the *process automation* provided by the computerized production system has significantly *improved* the clerk's *productivity* by providing the ability to perform his/her job more efficiently.

Further, each department head would be provided with a CRT or PC for access to the production system; *real-time* information on efficiencies, operator performance, downtime, quality, etc., would all be integrated into the system and available *on demand,* allowing him/her to respond quickly to any *out-of-control conditions* that exist on a more *real-time* basis. In addition, at the end of each shift the production system's disk drives would be utilized to archive *historical* data for each product by shift and process step. Software would be developed to *batch upload* the *historical* production information to the IS mainframe for use in cost or other financial/business oriented reports. The departmental CRT or PC would also be utilized to provide access to related main-frame reports which contain this data.

And the information could be made accessible to all authorized users by developing a network which provides a bridge for access to this facility's production system and all of the other computer systems at facilities company-wide. Information about the product would be provided as the product moves through each processing step and from one location/facility to the next -- allowing each facility to have advance notice of any special processing requirements *before* the product enters the facility rather than after processing has begun.

Productivity Gains

In such a case, there are no immediate quantifiable benefits which can be developed relative to process automation in the traditional return on investment (*ROI)* sense. However, there are a number of *productivity* gains that are achieved by this type of *process automation*. They include:

- *Improved Data Accuracy* -- errors associated with manual data collection will be eliminated; system validity checks will reduce data entry errors at all levels
- *Reduced Data Redundancy* -- data will be *captured* either via data entry stations or directly from computer to machine communications (at the machine); the repeated transcription of production data from department to department will be eliminated

- *Improved/More Real-time Access to Production Information* -- Data which was previously available at the end of an IS processing period will now be available on a *real-time* or *near-real-time* basis (after each event) to all authorized system users, allowing the status of each product and the overall facility to be continuously monitored
- *Improved Process Management* -- At each step of the process, department managers will have access to information concerning all of the various steps of the process. The system will provide a window into the process so that *out-of -control conditions* can be quickly identified and resolved
- *Improved Ability to Operate Multiple Facilities* -- Via the network, processes upstream (either within a facility or at external facilities) will have immediate access to the product's status and any associated processing problems -- allowing improved product flow/handling from one process step to the next

All of these *intangible* benefits will ultimately result in improvements at the bottom line that will reap *long-term cost-savings* --- better product quality, increased on-time-deliveries, reduced reworks, etc. , --- but seldom can an *immediate short term* dollar value be determined associated with these kinds of projects at project inception. *Yet if integration is to be achieved, these types of process automation projects must be completed!*

WHEN TO AUTOMATE

Process automation should be utilized to improve operations. As previously mentioned, typical operations which were once labor intensive are being automated to utilize computer technology to reduce labor, improve energy, utility, and chemical usage, and to improve capacities and overall production rates. This *process automation* should be extended from the machinery to the clerk and the department manager to the divisional vice president so that *computer technology* is not only used to provide *tangible* benefits (labor, waste, energy, etc.), but also to provide *intangible* productivity gains. *Remember, each time a machine or process step is modernized to increase production, to improve capacity, or to enhance quality, there is also an <u>opportunity</u> to extend that modernization effort (both forward and backward in the process) via integrated computer technology to include "intangibles" of process automation such that additional productivity gains are achieved. Seize the opportunity!*

HOW TO AUTOMATE

The computer industry has provided us with a wealth of tools for process automation. Everything from robotics, RFID (Radio Frequency Identification), RFDC (Radio Frequency Data Collection), bar-codes, voice activated terminals, data entry terminals, CRTs, PC's, PLC's (Programmable Logic Controllers) to full blown DCS's (Distributed Control Systems) are available for use in the automation effort. The tools selected are largely dependent on the application and amount of funding which has been allocated for project completion. *And size of the effort depends on the company's general philosophy or implementation strategy relative to process automation.*

<u>Developing a Plan</u>

"You gotta have a plan!" ..... so the old adage goes. Experience has proven that use of a plan for implementation of *process automation* facilitates the effort. First, the fact that a plan exists suggests that there is a commitment to proceed with process automation and that a strategy for accomplishing specific goals -- either *tangible* or *intangible* -- have been defined. Whether the plan is *top-down* or *bottom-up* is of little importance. *Typically* manufacturing/production personnel develop a *Five-Year Plan* for capitalization. This plan may include many aspects of plant operations, including proposed machinery upgrades and/or replacements. Information Systems (IS) personnel may have a *Strategic IS Plan* which details objectives relative to information flow/accessibility from a more corporate perspective -- addressing issues relative to marketing, customer service, inventories, cost, and financials. *Ideally* the *process*

automation plan should exemplify a *convergence* of *both these efforts*, assuring that each machinery up-grade includes process automation at all levels such that *manufacturing*, *IS*, and *corporate* goals are achieved.

Regardless of the methodology utilized for implementation of *process automation*, the plan should be methodical -- providing a step by step progression which *integrates* the specific goals of *production/manufacturing* operations with those of *corporate IS* and *corporate management*. The plan should include development of *production/plant floor systems for process automation*. These *production/plant floor systems* provide the *glue* necessary for this level of *integration*. When successfully implemented, these systems will provide a *seamless interface backward* from the office clerk to the operator at the plant floor down to the machine and *forward* through the department manager to the IS department to the Cost department and other support services personnel .... right on up to the Vice President and Chief Executive Officer. Via these systems, the *process automation* plan can be achieved.

Implementing the Plan

Believe it or not, developing the plan is the easy part! Implementing *process automation* can be tricky business, especially if everyone in the corporation is not on board with the process. Problems that can arise include everything from lack of plant management support due to fear that "*big brother*" will be able to watch how well (or how poorly) a manager runs his/her department to the fear by operations personnel that the use of a computer will eliminate jobs -- *including theirs*!!! One of the keys to the successful process automation effort is the ability to involve all of the individuals affected by the process. These individuals may include as many or as few of the following groups as are deemed necessary:

- **Manufacturing --** to provide input on the new equipment or procedures relative to required capacity, processing functionality; machine vendor selection (if applicable)
- **Industrial Engineering** -- to provide input on labor and material/resource requirements, production, labor, and related costs and savings, the ROI analysis, etc., (both with and without automation)
- **Technical Support --** to provide input on new products, markets, etc., that new equipment and/or any process automation would impact
- **Engineering --** to provide input on structural, mechanical, electrical, utility, and other requirements
- **Production Information Systems Group**-- to provide input on the feasibility of implementation of process control and/or process automation, including specification of the computers for process control and process automation and any related instrumentation (I/O) requirements for machine interface; this group will also be utilized to develop these systems where feasible
- **Plant Services** -- to provide input on installation requirements (wiring, power, etc.); based on control system I/O requirements provided by the production information systems group, types and quantities of instrumentation will be specified (if applicable)
- **MIS/DP** -- to provide input on the interface requirements for corporate information systems
- **Purchasing** -- to oversee the acquisition of all equipment (machinery, instrumentation, computers, devices, control systems, etc.) and related computer technology

Each of these *internal* groups must *assume* responsibility for its area of support *and* each must share in the responsibility for overall success of each process automation project. Once the *internal* resources have been identified an *internal alliance* or *partnership* should be formed which includes each of the groups involved.

Additionally internal support can be *solicited* from the operations work-force. Some companies utilize a *suggestion box* which awards *incentives* for implementing *process automation, especially for automation projects resulting in cost-savings*. Whatever the strategy, everyone must be encouraged to participate!

Filling the Gap -- Developing Partnerships for the Future

The company should also identify any *outside vendors/suppliers* of goods and services which may be utilized to supplement internal project support. These *external* resources can often-times facilitate the *process automation* effort. If any of the areas delineated above are not available as internal resources within a company, outside resources should be utilized. These support services may be contracted or *out-sourced* as deemed necessary. For example, the production information systems group may or may not exist. And the traditional IS group's personnel may not be familiar with developing the *real-time* communications drivers that are needed for plant floor machine/device interfaces. In such an instance, the company may choose to utilize an outside vendor for plant floor/production computer system development. Care should be taken that while *filling the proverbial gap* vendor dependency is not somehow engrained in the process.

Partnering can be utilized to clearly define these types of outside vendor relationships such that both companies mutually benefit from the effort and to assure that out-sourcing costs are contained. Via the formation of *external partnerships* or *alliances* additional incentives for business (reduced costs, reduced maintenance and support, reduced engineering, shorter project development time, etc.) may be provided. These *alliances* or *partnerships* may also provide the company with access to technical expertise within the vendor/supplier's organization. Any vendor who supplies a product or service used for *process automation* becomes a *share-holder* in the *success* of the *process automation project* for the *long-term* via the *partnership.*

PROGRESSING THE REGRESSION

Regression is defined in general statistical terms as the tendency of a parameter to go back towards the statistical mean. Literally, we say that we have regressed when we reason backward from an effect to a cause. Understanding the mentality towards process automation in textiles is a lesson in *regression analysis*.

For example, suppose a particular greige mill is producing poor quality cloth and production rates are inadequate -- too many stops, poor weaving efficiency, poor weaver index, etc. The typical *reactive* greige mill manager uses *regression* to explain this *effect* by reasoning backward to the *cause* -- the looms are older and speeds are too slow to produce desired quality and quantities of a fabric. The greige mill manager requests that the company spends *capital* dollars on more modern sophisticated micro-processor based looms which can produce better quality fabric at faster speeds and the request is approved. *Result* -- another island of automation is created which addresses one parameter in the *regression analysis*.

But what about the rest of the parameters -- *carding, winding, spinning, slashing* -- how do these processes affect the production at the loom? While the efficiency in weaving has been improved by this acquisition, has the company's overall bottom-line been affected? Further, has *process integration* been achieved; (i.e. is information about the performance of the yarn at each step of the process available so that as the product moves its processing history moves with it)? Too often companies take the first step by automating one part of the process but fail to consider backward integration to ensure that information from the newly *automated* process can be correlated with data provided from previous steps. Further, often-times the information provided by the new equipment is *inaccessible* to future processing areas/steps -- the information should be available across all areas of a company to determine impact on over-all company costs, efficiency, labor, etc.

The example above was given relative to greige manufacturing; however, the same kinds of issues should be noted relative to dyeing and finishing in textiles where machines are controlled via elaborate control systems but no dye mixing control has been achieved. *Rework rates* have been and remain high, *even after*

the modernization. In this case, there are real *cost-savings* associated with machine efficiency, labor, chemical, energy and utility usage's which have been achieved via the implementation of *process control*. But how much more is left on the table because dye mixes are inaccurately or erroneously made due to a lack of automation in the mixing room? How much dyestuff is dumped due to bad mixes? Do shade problems occur solely because of machine operations ??? Or does the consistency of the mix applied to the fabric also impact the consistency of the shade from dye run to dye run? Lower production rates and high seconds are often attributed to slower older machines; these machines are replaced with newer faster machinery. However, the *rework rate is unaffected*. *Why?* Reworks due to improper mix are often-times not reported; the increased speed of the machines may actually be utilized to *hide* the fact that even more productivity could be achieved if additional *regression* parameters were identified and a better best-fit equation were achieved. Again, this scenario is typical of an *incomplete regression analysis -- the rework parameter was not properly addressed in the regression!*

The process automation effort should epitomize an optimal regression analysis! First, all of the *critical* correlated *process* variables must be identified and their inter-relationships must be defined such that the *regression* is accurate. And *all of the key parameters must be regressed, so that not one but every part of the process that affects the end product can be effectively monitored and/or controlled.* Only then will the *expected value* of each of the jointly correlated *process variables* approach more closely the *mean value* of *its* set in the best fit sense. *Only then can the process automation effort result in change*.

AVONDALE MILLS -- A CASE STUDY

Avondale Mills, Inc. is a billion dollar textile company which is the third largest denim manufacturer in the United States, the ninth largest company in Georgia, the second largest employer in South Carolina, and the largest cotton consumer in the United States. The company recognizes that in order to continually compete in the *global market-place*, it must continue to produce high quality products cost-effectively. Avondale recognizes that *process automation*, including *process control*, must be an integral part of that effort. In order to maintain its status in the United States and around the globe, the company has committed to the use of *process automation* in its greige manufacturing processes and *process control* in its dyeing & finishing and indigo dyeing operations.

Avondale utilizes a *team* approach to *process automation*, forming *alliances* with each of its internal groups -- manufacturing , industrial engineering, technical services, engineering, *AIMS*, MIS/DP, purchasing, and plant services -- to ensure that every detail of the process automation effort has been adequately addressed and that projects are successfully completed.

The typical *process automation* or *process control* project at Avondale begins with a *Capital Request* for a project from Manufacturing. This type of request is usually accompanied by an *ROI* analysis which has been developed by Industrial Engineering personnel. Once the request has been received, the requirements for successful implementation are defined. All of the *internal* groups involved in the project are identified -- engineering, plant services, MIS/DP, and AIMS personnel -- and the *partnering* begins. Typically *capital* projects require that all of the previously mentioned team members *discuss* and *coordinate* their respective tasks so that time schedules are met and each task is completed successfully. Vendors and suppliers are brought into this *partnership* via *formal* or *verbal* agreements which ensure that they *too* are committed to overall project success.

AIMS, Avondale's Integrated Manufacturing Systems, is the technical group responsible for in-house development of computer systems for *process automation and process control and is an integral part of this effort*. The group is divided into three functional support areas/groups -- *Process Control*, *Digital Equipment Corporation (DEC) Systems*, and *Greige Manufacturing*. These three groups provide support for manufacturing computer systems, process automation, and process control at Avondale Mills. Technical applications completed by the group range from design, development and installation of process

control and process monitoring systems to development of on-line, real-time networked Statistical Process Control/Statistical Quality Control (SPC/SQC) data for the company's production facilities and QC laboratories. Interface of the process control systems to the on-line reporting systems is also an integral part of the group's activities. AIMS activities include responsibility for each of the twenty-six (26) manufacturing computers and two (2) distributed control systems (DCS's) at the Graniteville Fabrics division, support of the two (2) manufacturing computers at the sites in Sylacauga, Alabama, and support for a wide variety of peripheral devices, including terminals, networked line drivers(T-NET), spectrophotometers, and data units associated with those systems, as well as the interface to other computers on the company's Corporate Wide Area Network. The use of this in-house technical/manufacturing systems group has significantly facilitated the development of systems for plant floor automation at Avondale. In-house development has both *reduced* the *up-front* cost of the systems necessary for *process automation* <u>*and*</u> it has also *reduced* the *long-term* cost of system ownership relative to support, customization, and maintenance.

The process automation project at Avondale, whether *capital* or not, often-times results in a *Project Request for AIMS* support. *AIMS* personnel develop a *Functional Specification Document* which details the scope of work to be performed, any support areas (such as *instrumentation*, etc.) which must be addressed and any associated costs. Once *User Sign-Off* is obtained, an *Action Plan* is developed and project development and testing begins. Projects for process automation and process control which have been completed by AIMS for Avondale include:

- Designed, developed, and installed all Control logic, Configuration, BATCH90 Software, INFI90/NET90 hardware I/O requirements, graphics, trends, databases, and MCS and OIS-40 Console Displays for the Bailey Controls Process Control System which controls processing on twenty-six (26) textile machines in three (3) different processing areas -- Preparation, Dyeing, and Finishing at the Gregg Dyeing & Finishing Division. The system also monitors lot status of a total of forty-four (44) production machines at the Gregg facility
- Designed, developed, and installed an A-Frame/Lot Tracking System for forty-four (44) machines at the Gregg Division
- Designed, developed, and installed GAMMA γ (Graniteville Application Modules for Manufacturing Automation) Systems for Loom Monitoring at both the Sibley and Hickman Greige Mills
- Designed, developed, and installed an A-Frame Locator System for control of IPI (In-Process-Inventory) at the plant floor level at the Gregg Division
- Designed, developed, and installed an automated Machine Time Sheets System for machine efficiency reports at the Gregg Division
- Designed, developed, and installed control logic for Peroxide Analysis in the Preparation area at the Gregg Division
- Designed and developed a control system for Automated Mixing at the Sibley Division
- Designed, developed, and installed control logic for Automated In-line Mixing at the Gregg Division
- Designed, developed, and installed control logic for Dye Caustic Mixing for the Gregg Division
- Designed, developed, and installed Real-time Production Monitoring, Reporting, and Graphical Trending Systems for Gregg and Indigo Dyeing divisions
- Designed, developed, and installed a Networked SPC/SQC Data System which allows on-line access to SPC/SQC data from the Quality Labs and process areas at all greige mill and dyeing and finishing AIMS sites
- Designed, developed, and installed software for automated payroll and production data transfers to MIS/DP systems
- Installed BARCO Loom Monitoring Systems at two (2) of the Greige Mills and developed associated customized production applications

* Installed a BARCO Fabric Inspection System at Sibley Dyeing & Finishing System and developed associated customized production applications
* Designed, developed, and installed all Control logic, Configuration, BATCH90 Software, INFI90/NET90 hardware I/O requirements, graphics, trends, databases, and OIS-41 Console Displays for the Bailey Controls Process Control System which controls two (2) state-of-the-art Indigo Dyeing machines, a Mixing Platform, and Bulk Storage Tanks at the new INDIGO Dyeing facility

The group is currently being utilized to develop *APICS* (Avondale's Process Integration and Control Systems) for a new Weaving facility that is scheduled to be brought on-line in 1998. *APICS* will include *process automation* at each step of the process at the facility, including *process monitoring* in weaving and *process control in* slashing. The system will be integrated with the existing control system at the facility. And *APICS* will be accessible, like all of the other systems developed by *AIMS*, via the corporate network.

CONCLUSION

The **Mission Statement for Avondale Mills, Inc**. , states that the company's mission is to develop *partnerships* through relationships, information, and product with its *suppliers*, *associates*, and *customers* which create value and the opportunity for each to grow and profit. The company has utilized these *internal* and *external* partnerships or *alliances* in its automation strategy. *AIMS*, Avondale's Integrated Manufacturing Systems group, is one of the partners of the *internal* alliance team which has been successfully utilized to develop in-house systems for *process automation*, including *process monitoring* and *process control*. The systems which have been developed by *AIMS* have improved productivity at every step of the process. These systems have been integrated so that information about the product is available to authorized users company-wide. And Avondale's plans for future modernization include continued *process automation* with the help of *AIMS* and the company's other external and internal alliances.

Avondale Mills is *progressing* in its effort towards a regression analysis which includes a *best fit polynomial* with parameters for *process automation* at each of its processing steps. *Exponents* at each step are clearly defined by the company's facilitators -- both *internal* and *external* resources -- who make sure that at each iteration *integration* is also achieved. And Avondale is uniquely positioned with its own *in-house* set of experts -- groups like *AIMS* -- who utilize these techniques over and over again until the regression is *complete.* Via this *process automation* effort, *Avondale is making change!*