Pulp and Paper Automation Service Solutions for the 21st Century

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Abstract

Analysis of quality control and automation systems (QCS) in the Paper Industry indicates that up to 75% of those automation investments are not providing benefit. Rather, they are creating process problems instead of solving them due to the lack of a comprehensive service program. No longer is service limited to mechanical devices. As automation improves and paper mills become more integrated, the need to expand the definition of service to include the automation systems and process applications is required.

ABB is an industrial automation solution provider and delivers solutions to such industries as pulp and paper, oil and gas, minerals and mining, power, and marine and turbo for years. As a result of our experience we have noticed significant trends in services needed to extend the life cycle of an automation system as well as improving the performance of those automation and QCS solutions. We now have over 1000 years of service activity recorded and are able to define service distribution models that address today's service requirements regardless of the manufacturer. This paper highlights preventive, reactive, and optimization (process) service models that have been proven to increase production, quality, and reduce the cost to produce. Today's service requires advanced solutions based on the latest technology coupled with proven methods to ensure the optimal distribution of service effort.

Introduction

Pulp and Paper is an industrial process that converts raw materials into a product that can be sold. The physical equipment used in the conversion is vastly different between industry segments such as kraft, newsprint, fine writing, newsprint, medium, specialty, etc. However the automation and quality control system used in the conversion can be very similar. The automation system involves instrumentation, actuation, controllers, computers, platforms, operator displays, data storage, alarm management, safety systems, drives, continuous control, and the list can grow from there. The following general use diagram illustrates how Industry specific equipment, automation systems, and production or operations comprise the fundamental components related to converting raw materials into a product.

![Diagram of raw material conversion process](image)

Automation systems are now found in virtually every area of paper making including, pulping, bleaching, effluent, stock approach, Fiber lines, headbox, paper machine, drives, reel building, re-winder, super calendar, and converting. In each case, the goal of the automation system is to control this conversion process most effectively, efficiently, and with the lowest cost to produce. Most companies recognize that production rates will be impacted by equipment that is broken or worn. As a result, hardware service is an essential part of the financial picture of paper mill operations. However, financial savings related to
service that is applied to automation systems are just today starting to be understood. Not that long ago a control system was made up of a controller physically mounted to a wall. The wall space defined the size of the automation solution. In many cases these solutions were slow, difficult to use, and didn’t have a huge impact if they were turned off. Few companies felt the need to spend a lot of money on service maintenance to look after an automation solution that didn’t provide bottom line results. Today that mindset is changing. Advances in technology have driven the evolution of automation solutions to provide displays, controls, safety, alarms and control algorithms that could not have been dreamed of even 10 years ago. Automation systems are now a vital part of the production process. In many cases, if they go down, the industrial equipment must be stopped because the operations teams cannot operate these assets or produce the quality expected in the final product without the automation system information. Consider the automation that has become part of our personal lives: smart phones, notebooks, mobile devices, home automation, navigation systems, flat screen televisions, security systems, cover only a few of the technological advances that we now consider standard. The industrial world has moved to improved technology to solve today’s problems. As a result, a new field of service is required.

This paper focuses on not just the quality control system of the paper machine, but all automation systems used in today’s pulp and paper mills. Standard service solutions are critical for ensuring the continual improvement of the financial picture of any the pulp and paper mill.

**Automation Overview**

An automation system is much more than a single loop controller mounted on a wall. Today’s automation systems integrate tightly with industrial equipment. As a result, a few definitions of terms related to automation systems are in order. No longer is it enough to say the frame is scanning and measuring so I am done. There is actually a hierarchy of automation levels. Each level is dependent on the previous. An overview of this hierarchy looks as follows:

In yesterday’s automation, a control system was thought of to include the three lower levels of this triangular hierarchy. We would make sure the chart recorder had ink in the pens and paper in the charts. Occasionally we would check the pneumatics to make sure we had pressure and clean air. The focus of those early control systems was to regulate to a reference point when faced with either a change in reference or a disturbance. These early advancements allowed operators to spend more time on the process and less time moving an actuator. Today’s automation systems further aid operators to allow them to focus on production and quality issues. Now a control system includes all of the areas of the hierarchy. If any one of these areas falls short, the result is variability in the production, quality, or cost to produce. Even though variability is not a function of the automation system, automation systems were put in place to reduce variability and increased productivity.
As great as modern automation systems are today, they don’t run themselves. They are made up of hard drives, controllers, monitors, jumpers, firmware, software, and hardware. If you ignore a fan, a controller can overheat and result in an entire portion of a plant being shut down. Likewise, the control platform can be perfect, but the application running in the software can be outdated and result in insufficient update times for operations. Recently a customer was concerned that his automation system was not providing the expected levels of production and quality. The reason quickly becomes more apparent when we applied the latest data mining service tools.

What we found was disturbing; the very control system that was designed to improve production was actually decreasing production. The trend shows a dip in production (top trend) that occurs at exactly the same time the control system is turned on (bottom trend). As a result, they reverted back to running the plant in manual. On the one hand, how can you blame them? Operators don’t make it a habit to turn off features that make the plant easier to operate. On the other hand, why was this automation system failing so badly? Further investigation showed that this customer had never performed any service on their automation system.

A common belief is that once an automation system is installed, it should work with no additional intervention and with no periodic service. This is actually a false assumption. In fact, we are finding these automation systems are very dynamic and have to be checked and calibrated on a regular basis. One startling finding is that control loops have a half-life of approximately 6 months. This is a little hard to believe in that it means that if 100 control loops were perfectly set up, 50 would need attention in 6 months. The actual percentage depends on the industry and environment, but it holds pretty true as a rule of thumb. The question becomes, “When was the last time you checked your automation controllers?” We are finding the answer is, “not very often” or “when we installed it”. The result is a performance distribution that is a pretty bad commentary on the state of automation in many of today’s industrial companies.

- 30% Manual Operation
- 15% Out of actuation range
- 30% increasing variation
- 25% improve production

These results indicate that nearly 75% of the automation capabilities designed to improve production and reduce the cost to produce are either doing nothing or making the problem worse. The following is an example from a customer that had done no service on their automation system for several years. They were losing money and finally asked that we take a look at their system to see what we could find. The customer had an automation distribution as defined earlier and typically ran their plant in manual. When we tried to turn on the automation system we found that the plant production went unstable. We looked
further and fixed the actuation, recalibrated the instrumentation, updated the application, made the user interface easier to navigate, and finally updated the tuning parameters. The result was a series of successes that netted the customer over 10 million dollars a year in savings.

Another example from an industrial boiler follows the same script. In this example, the customer had pretty much given up on their automation system. They had been running their boiler in manual for years. However, when gas prices went up, they could no longer afford to run the boiler in such an inefficient manner. That is when we got the call. Upon arrival we found that no service had ever been done on the automation system. We found bad actuators, rusty positioners, leaks in the chamber, and function modules that were not up to date or calibrated properly. This graph shows the oxygen to steam load in 1 hour averages for a year before and after our service work. The scattered blue dots were before; the yellow solid line that looks like a hockey stick was after the work. This was a savings of over 100kUSD per year. They were no longer heating air that was going up the stack, but getting the steam they needed with less gas. In the graph a few pink outliers occurred when the operators reverted back to their old habits of manual operation.
The improvements shown in these two cases are not uncommon. These results are what automation systems are designed to do. However, with no automation service these systems become unstable and unusable. The financial impact to production resulted in both customers asking us for an automation service solution that would ensure their results do not erode over time and that makes the benefit of well-tuned controllers sustainable.

**Service Types**

In order to insure that an automation system provides financial gain, service is required. In general terms there are two classes of service activity: Preventive and corrective. Unscheduled corrective maintenance is expensive and usually is initiated after a failure. Failures are unscheduled and can happen at any time. When they occur they can result in decreased production. Preventive service is cost effective and is designed to reduce the risk of such failures in the first place. We have found that if the ratio of corrective to preventive hours spent exceeds 5, then the preventive maintenance is either not being done properly or the wrong preventive maintenance is being done. In general the more preventive maintenance that is done, the less unscheduled corrective maintenance will be needed.

The fundamental difference in preventive and corrective service programs has to do with proactive and reactive maintenance. Reactive maintenance waits for the problem to occur before initiating a correction. Proactive service attempts to reduce the risk of an unplanned downtime with regular preventive maintenance activities. The following shows a trend of work order tasks for a customer that moved from a reactive to a proactive service strategy.
The concern people have for deploying an automation service solution is that it will add additional cost with no value. This is not the case when the preventive maintenance is properly distributed and tracked. Notice that as the proactive or preventive maintenance program on the automation system went up, the number of unscheduled reactive corrections went down. This has a direct impact on overall equipment efficiency and results in increased production due to less unscheduled down time. In other words, the proactive service is much like adding weeks of production to the year with no additional cost.

**Service Methodology**

In order to ensure that the Automation System is running at peak performance, three fundamental areas need to be identified and addressed:

- Service Distribution
- Service Skills
- Service Tools

When these areas are addressed, the balance of preventive and unscheduled corrective will fall into line.

**Service Distribution**

The trick is knowing the right distribution of service activity and then managing to that distribution. We have found that when we manage to the following automation service distribution we dramatically improve the financial picture of our industrial automation customers.

![Service Distribution Pie Chart](chart.png)

ABB has been involved with refining this distribution for over 30 years. The distribution is a percentage of time spent in each service category. The service categories are:
- Preventive – Service that is done on a scheduled basis that involves physical inspections or measures.
- Support - Service related to operator training and technical training
- Administration – Effort to maintain the service maintenance schedule
- Scheduled Corrective – Corrections that are found during preventive maintenance that can be scheduled during an upcoming down time
- Optimization (of Process) – Service activity aligned with performance, quality, or production improvements
- Unscheduled Corrective – Corrections for failures that were not caught during the preventive maintenance schedule.

This service work can be done by anyone, but the distribution and the content of the service being done are very important. Recently we were called into a global customer to help them unravel a problem they were trying to solve. They had two sites on the opposite sides of the world that could not produce the same level of production and quality. Both sites had the same industrial equipment, same automation system, and same production and quality specifications. After much evaluation of service activity the following distributions made the production and quality issues became more apparent.

In this chart the blue line represents the optimal service distribution. The rust color bars represent the distribution from the site that was hitting the production and quality specifications, the green bars represent the site that was not meeting quality and production standards. Notice that the service activity related to support, administration, and scheduled corrective was nearly the same for both plants. However, the glaring difference had to do with the time spent in preventive and unscheduled corrective. This pinpoints the issue. The site that was hitting the mark had adopted a service philosophy of proactive service while the one that was failing had a reactive service philosophy. Service philosophies are difficult to change, but when confronted with this data and the financial loss that correlated with a reactive service culture, the customer started down the road of proactive services. Another interesting observation shows that the time spent in the service area related to optimization or advanced services was more for the pro-active service minded site. This is also not uncommon for clients that are pro-active in their service stance. Since they have a better handle on their automation system, they have more time to spend aligning the automation solution with the industrial equipment for the product being made.
Service Skill mapping

The service distribution is only part of the story. Both sites had a similar number of people working on the automation systems. However, the skill distribution of both groups was significantly different. The proactive client employees had on average more than 3 times the training of the reactive client employees. Unfortunately this is not uncommon to see for reactive service philosophy minded customers. The thinking is that once the system breaks, we know what to fix, so why train? This is a mistake and results in frustrated engineers that take longer to solve a problem and are unsure of the best practices to use to make sure the problem does not come back. Proactive minded clients have seen the benefit of this service philosophy and they see training and certification as an investment to ensure not only results don’t erode but that production and quality performance continue to improve.

Service Tools

Sadly, the comparison of the two sites had more problems that don’t fit only into service distribution and service skills. The reactive site had not kept up with modern service tools. Service tools can be software or hardware components designed to improve the efficiency of proactive services. As a result any type of data mining or unit specific testing could not be done by the reactive client. They simply did not have them because they felt the way they had always done service would be fine for today’s systems. This simply is not the case. No longer can you look at the amount of ink in a chart recorder to see if you have a bad valve. We have more data available to us today than ever before. As a result, simple observations made in the past will miss most problems that are obvious when mining data and information. Not only did this client not utilize modern tools, they did not capitalize on the remote solutions that are now available. Only the most serious failures were considered worthy of bringing in an outside consultant to fix. This increased unscheduled downtime, increased service visit costs, and further compounded their distaste for their automation system.

The following example shows a suite of tools related to control loop tuning and analysis that should be on every automation service work bench. The volume of information that is present in today’s automation systems requires high power technical tools to manage the data and quickly drive to conclusions. Consideration must be given to data collection, loop setup and calibration, data mining analysis using Fourier and statistical methods, process identification, tuning and simulation, process interactions, and root cause analysis. The ability to quickly document results in standard reporting packages is also an essential element.
Automation Services

The automation system and equipment is an integral part of operations and cannot be left unattended. Realizing the full potential of the automation equipment requires service, but what service? The goal of service is to reduce unscheduled down time and improve production and quality. If these areas are in trouble then the automation system is very likely not working. There can be several reasons, but one of the first areas to focus on is getting the service balanced. In order to help realign automation services the following table can be used as a guide to help define the white space in current automation service programs. A well balanced service program must include the following:

- Proactive maintenance plans – Keep track of work done
- Focus on utilization of the automation control system
- Problems fixed when they are identified and corrections recorded
- Access to support
- Dedicated Service Hub that is separate from the control network.
- Up to date tools for efficient data mining, troubleshooting, and implementation.
- Certification and training programs to ensure individuals are qualified to perform service.
- Periodic evaluations to ensure that the ratio of preventive to corrective maintenance is being maintained.

This table is not meant to capture all areas of automation service, but rather provides a place to start. The four areas related to hardware, platform, utilization, and people need to be balanced so that nothing gets missed. The area in the middle is a detailed list of areas that need maintenance activity. Each of these items will have work order schedules, items to check and record, parts lists, parts kits, replacement frequency, and more. If a failure happens with any of these items, the automation system will become a barrier to production and quality.

In today’s automation systems, there are no longer only a few controllers that can easily be physically inspected. Today it is not uncommon to have 100’s if not 1000’s of automation devices in a single industrial setting. Efficient service cannot be done the way we did it 10 years ago. Tools that leverage our people are required in order to cast a net on the entire automation system to ensure nothing gets missed. The bottom set of squares represent tool categories that need to be filled with commercially
available solutions. These solutions are often software packages that provide the tools necessary to build a well-balanced automation service solution.

**CMMS Systems**

There are several commercially available Maintenance management systems on the market today. A computerized maintenance management systems (CMMS) is used by service engineers to collect, manage, and apply best practices for servicing the automation system. A well-established CMMS system ensures that the automation equipment is serviced efficiently and cost-effectively. Managing service activity results in increased automation equipment efficiency, reduced process reliability, extended system lifecycles, and reduction of the total cost of system ownership. Users have access to reliable historical information that provides insights for continuous business improvement.

When evaluating a CMMS system, be certain that the following features are present.

- Multi-site synching of global information to a central database.
- Service activity recording based on preventive and corrective maintenance.
- Compare site activities to those at other internal company sites.
- Service completion and failure rate comparisons with global averages.
- Equipment support time comparisons with other sites.
- Equipment life cycle status information.
- Parts inventory and condition management.
- Parts risk assessment and analysis.
- Parts order tracking and repair status.
- Site statistics and KPI’s (Key Performance Indicators) easily monitored by managers so they can quickly address problems.
- Standard library of best maintenance procedures and work order tasks for each asset.
- Flexible reporting package with standard report templates.
- Support for both internal and external users.
- No additional manpower needed to maintain and manage software.
- New version releases and updates automatically downloaded at no cost to the customer.

**Remote Enabled Services**

The continued advancement of the internet is changing the face of service delivery dramatically. In the past, service could only happen when a service person conducted physical service at site. Today, secure network connections and the technical sophistication of automation have enabled a new world of remote enabled or remote capable services. These new services dramatically reduce travel times and provide access to experts in seconds. No longer is it necessary to order service work in chunks of a week. We can provide service at the highest level possible nearly instantly. However, with this new power also comes a risk. We are being faced with cyber security attacks on our automation systems. As a result, a new field of cyber related safety needs to be considered to ensure that no one inadvertently puts a bug on your control network. The threat of cyber infection on an automation system can be catastrophic.
Service Hub

One way to further reduce the risk of cyber threats to the control system is the concept of a service hub. A service hub is a service node that is separate from the control network. This hub provides service access to the control network from a central location. This limits remote connections to the site and reduces the risk of service work causing the control network to go down. In this way, access to service relevant information is possible without exposing the control network to potential attacks. A framework that allows for this interaction can be seen in the following graphic.

In some cases remote connections are not possible; however local support should be routed through the same interface. This reduces the risk of failure to the control network and opens the potential for expert access.

Conclusion

Consider the following; a friend of yours gets a new car. Several months later he is devastated that his car died on the side of the road. You are surprised that a new car would leave your friend stranded. So you ask the type, model, and then get to the service history records. At that point, you find your friend never changed the oil, never checked the tires, and never paid attention to any of the dash warning signs. You might think that your friend is not that clever. Besides, everyone knows service on even the most expensive car is necessary. However, in the industrial world comprehensive service on an automation system seems to be thought of as a waste of money. The 20th century service culture is outdated. The 21st century solution to a comprehensive automation system service requires a different way of thinking about service. However, when the shift in service practice is made, it results in the cost and quality differentiators that drive industrial automation companies.
Designed to Improve Performance

Automation systems are designed to improve production and quality when they are turned on. If your automation solution is standing in the way of quality and production, then it is broken.

The last graphic shows that production and quality should improve when the automation system is being properly utilized. All too often we see poor automation service practices resulting in escalating customer dissatisfaction in their automation system. The following is what we have found to be the four phases of customer perception of their automation system when they have an un-balanced automation service portfolio.

The four phases of a reactive service minded client.

Phase 1 – This system is awesome! Typically at project installation and startup, there are many people working on the project, everyone is focused on the success of the system. The new technology is so far advanced that even a partially calibrated system provides significant production improvements.

Phase 2 – We fix the system when it breaks. Project team has left and the system is working well, but system expertise is lacking. Problems are operator driven from a reactive perspective. System still providing good results.
Phase 3 – Why do we have this system? Repairs took too long, operators figured out other ways to solve production issues. They may be less effective, but waiting to get the control system fixed takes too long. System only used in emergencies or until it can be turned off so operators can manually operate the plant.

Phase 4 – We purchased a bill of goods! Production and quality are in trouble. Defects are costing profit and the bottom line is not looking good. This automation system was a waste of money. How can we get rid of this thing? Why did we ever get it?

Being an automation provider, we can assure you that no one sat in a room to design a product that would make production and quality worse. A pro-active automation service solution can even change the progression of phases from “this thing is terrible” to “this is the greatest system in the world.” Recognizing that an automation system, when left on its own, will degrade is crucial. The trick is to add proactive services to fill in the performance gap. When this gap is taken into consideration, then positive financial results can be achieved.

Continuous Improvement with a Proactive Service Strategy

Continuous improvement is an integral part of a comprehensive service strategy. Utilizing the latest service tools in process performance may seem to be an unrealizable dream that has a cost that outweighs the return. However, we have found quite the opposite to be true. Many times, the annual return to our customer’s bottom line is in excess of five to ten times the investment in the automation service. A well-balanced automation service solution is within reach and results similar to the following are not only possible, but expected. A 250kUSD annual savings was realized when the automation system was properly maintained.
Automation system services are required for today’s automation systems. When they are ignored, it is much like wondering why my car’s engine just overheated even though I never changed the oil. All industrial systems are different and rarely do any two require the exact same type of automation service. The goal is to formulate a well-balanced service solution that covers the following:

- Reduces unscheduled down time
- Improves production
- Reduces the cost to produce
- Improves quality

In addition, the automation service solution must provide:

- A means to effectively manage and track service distributions and activity
- A measure of skill training and certification
- A set of technical tools aligned with the automation platform and process
- Access to a secure remote enabled support structure

In order to realize this goal, service on the automation system is required. Financial and quality gains are only possible with a proactive and well-balanced automation system service solution.