Control Systems at ITMA 2003

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ABSTRACT

A comprehensive analysis of the current trends and technologies in control systems for the textile industry is presented. Our approach was first to dissect the important components of an integrated control system and then to determine if and how the components are converging to provide manageable and reliable systems throughout the chain from fiber to the ultimate customer. Although the implementation of advanced process control strategies is not foreseen in the immediate future, it is apparent that the textile industry is slowly moving toward modular machines and systems. The dedicated systems still prevalent today are gradually being replaced by standard units, distributed automation concepts and an increasing connectivity of the production floor with planning and scheduling systems. This level integration has the potential to optimize the information flow throughout the entire Supply Chain.

Keywords: Control systems, Supply Chain, information flow, process control.

Introduction

The “Control Systems” assignment was appealing to the three faculty assigned to the topic because of its breadth of subject matter. It allowed us to think of control systems from the machine level to the Supply Chain.

The official ITMA 2003 Catalogue contained 533 listings under the general topics “Software Design, Data Monitoring and Processing, (CAD/CAM/CIM) and Integrated Production. Some of the listings were redundant; however, the sheer number of them is representative of the interest and importance of these topics to the industry. In addition, the listings included companies from around the globe.

The following table indicates the distribution of activities involved with the 533 exhibitors:

| Table 1. Distribution of System Activities          |          |          |
| CAD (Computer Aided Design) vendors               | 116      | 22 %     |
| CAM (Computer Aided Manufacturing) vendors        | 217      | 41 %     |
| CIM (Computer Integrated Manufacturing) vendors   | 144      | 27 %     |
| Integrated Production vendors                     | 56       | 10 %     |
| Totals                                           | 533      | 100 %    |
The large number of CAM exhibitions could be anticipated, given the continued development of sensing technology and on-the-floor machine control evident at the show.

Each of the 18 halls contained one or more exhibitors in this area, which indicates the interest within and along the entire supply chain.

The following table summaries the effort within each manufacturing area using the 477 booths related to CAD, CAM, and CIM.

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<th>Table 2. Distribution of System Booths to Greige Area</th>
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<td>Spinning</td>
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<td>Weaving</td>
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<td>Knitting</td>
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<td>Dyeing/Printing/Finishing</td>
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<td>Embroidery/Make Up</td>
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<td>Totals</td>
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The great emphasis on weaving and wet processing can be explained somewhat by the failure of some the yarn machinery manufacturers from showing and the smaller than usual knitting machinery exhibitors due to their recent trade show. However, the weaving and wet processing exhibitions had the largest allotted floor space.

**Plans for Show Coverage**

It is difficult to assess the true value and potential of the countless number of “control systems” on exhibition at the show. Just as there are “show speeds” for equipment, there are “show screens” for computing software. Our approach was first to dissect the important components of an integrated control system and then to determine if and how the components are converging to provide manageable and reliable systems throughout the chain from fiber to the ultimate customer.

A second plan was to visit a wide variety of exhibitors to gain insight into their thinking across products, countries, and directions. This report reflects a summary of these two approaches.

**Greige Manufacturing Observations**

For years we have been discussing the need to convert data into information and finally into actionable knowledge. Unfortunately, some of the early booths visited seem to overlook the difficulty in converting data into useful, actionable knowledge. It was evident after visiting the exhibitors of sensing technology that their technology can measure more properties, variables, or events at an ever-increasing frequency. Thus the accumulation of data grows at an alarming rate. Because of the proprietary nature of many of the sensors, the companies have little interest in “sharing” their data collected in an open environment.

The knowledge chain can be exploded from the back of the chain (micro to macro level) or collapsed from the front of the chain (macro to micro level). The conclusion seems obvious. However integration needs to be driven from the front of the Supply Chain, which does require an open environment.

During the past few years giant leaps forward have occurred, making the progression more easily. The following sections of this report support this optimism.

It was only a few ITMA’s ago that Ethernet connections began to be offered at the machine level with less than 10% of the equipment shown with such a connection. The tremendous progress evident in 2003 was the result of parallel developments in each of six major components of an entire Integrated System:

1. Data Connectivity
2. Data Accessibility
3. Control Systems/Machine Interface
4. Human Interface
5. Information Systems
6. Integrated Systems

The ability to couple selected components from any of the developmental areas provides the potential to optimize information flow throughout the entire Supply Chain. The next few section will summarize each of the above six areas.

**Data Connectivity**

Data enablers have increased the communication ability between devices over time as seen in Figure 1. The ability to gather and pass along information in the textile industry has closely followed the technological advances in computers.

![Figure 1. Historical Evolution of Data Connectivity](image-url)

At one time, most machines came with very little or no sensor capability. The advances of the computer and network capability has given way to the explosion of sensing capability, storage, and process of that data for control. Earlier sensors did not come as standard equipment on most textile machines. Hard wires were run into PLCs (Programmable Language Controllers) on the manufacturing floor. Typically, these connections were unidirectional from the information being sent. If the machine had sensors, getting access to the data in real time or in batch time was impossible unless you tapped into the machine’s PLC directly. The advent of the RS232 port (serial connections) opened up the machines to gain access to sensing data that was available. However, each machinery
manufacturer utilized a different protocol to gain access with its machine. This was an attempt by the machinery companies to keep their programmers busy with customers as well as keep their data propriety for their control systems. Even as standard protocols for accessing the machine become more popular, machinery manufacturers did not share their data formats and still required major programming for customers to access the data. Even today, this trend has continued. A majority of the major machinery manufactures still do not have an open database system or utilize a standard database structure.

Because of lack of portability or transferability, access to the control systems/data was limited to the localized area. Ethernet and the acceptance of the TCP/IP protocol worldwide opened up the ability to access the data in many different places rather than the manufacturing floor. The data/information can be easily transferred from a local PC onto the company’s network and stored in their information systems. Most of the ERP systems were Ethernet capable before machinery data. At the 1995 ITMA show, only a handful of manufacturers were placing standard Ethernet network connections in machines; therefore, forcing a PC to be the connection between the RS232 port and the rest of the network. However, in 2003, almost every machinery company utilized Ethernet connections along with the standard protocol of TCP/IP for bi-directional communication with their machines.

**ITMA Examples**

WeaveMaster™ from BARCO as well as Loomdata4™ utilize the standard TCP/IP protocol to setup a connection with a company’s ERP system in order to download the weave schedules as well as upload work-in-progress reports, efficiency, and quality data on stops and defect information if equipped with on-loom inspection automatically. This was made possible since SQL compliant databases are used by both systems as well as the company’s ERP system (See section on **Information Systems** for more information). By having direct access (i.e., the PC acts as the proxy between the company’s information system and the actual machines), lead times are decreased since no information has to be transferred manually and changes to schedules can be seen immediately (i.e., production schedules are updated) as well as any production problems that may require shifting of schedules. Plant managers and production personnel can now easily monitor and improve the weaving operation from anywhere in the plant through the powerful production report applications in both tools. The latest generation of microprocessor based looms is equipped with an Ethernet interface for host communication. These looms can be connected to the WeaveMaster™ or Loomdata system by means of a standard Ethernet network (UTP 5 cable) without the need for any additional hardware interface.

As the standard protocol for transfer of data from one device to another has been established, the World Wide Web (WWW) explosion built upon TCP/IP and another developed standard protocol for displaying information (HTPP) via the Web has caused a leap in information access. Again everyone has accepted this standard, which make it easy to access and display information. We think of the Web as a place of information display, but it can be used to manage the business through access to the company’s information system, to advance shipment notices from suppliers, to orders from customers, etc. See the session on the **Information Systems** and how they are utilizing the web to manage the business.

Another example seen at ITMA 2003 is the ability for the dynamic reports generated by various systems to be sent directly to a company’s web site. For example, BARCO introduced a new extension to its WeaveMaster™ Production Monitoring System, which allowed the automatic export and viewing of reports in a website environment. This Web reporting module allows traveling managers to keep close control over the operations in their plants anywhere in the world via the company’s website and have access to any of the...
WeaveMaster™ reports used within the office. Companies operating multiple production sites can use this module to centralize production management reports from all sites through out the company’s intranet infrastructure. The next phase will be for companies to use the Web reporting capabilities of these various systems to share information about production, planning, and quality with their customers or allied companies.

To this point, production machines and servers have to be connected using wired Ethernet. As new technologies are accepted by the computer industry, the textile equipment manufactures and systems generally follow closely behind. In 2000, 802.11b became the standard wireless Ethernet networking technology for both business and home. With a realistic throughput of 2.5-4Mbps, it is fast enough for most network applications and tolerable for file transfers. Having wireless Ethernet will allow companies to gain access to machines without having to run wires. This is a benefit, but the real advantage of wireless is it will give rise to a whole new class of monitoring and detection in the manufacturing environment that has not been seen. Using PDAs (portable data assistants), web enabled phones, or laptops with wireless networking, allows immediate access to the systems thus cutting down lead-time owing to maintenance and production efficiencies.

During ITMA 2003, BARCO was one of several companies starting to utilize wireless technology. They were using a series of wireless data collection hardware for the WeaveMaster™ and KnitMaster™ monitoring systems. These systems would relay there information to access points which would then send the information to the various information systems. Weave supervisors/production managers holding PDA with wireless capability can monitor their looms remotely. If a condition arises (i.e., they might be using on-loom inspection) that stops the loom, the supervisor can see all of the looms and select the one that has stopped. The conditions for stoppage is displayed along with a picture of the defect if applicable, the person can override the error and the machine error light can be turned off and a operator can restart the machine. In other cases, the supervisor can make a decision on the difficult of the stoppage condition and have the proper people notified.

A greater benefit really occurs for the maintenance crew. Technicians will be on the floor and will have the ability to see all of the stopped looms and conditions for stoppage. They will be able to prioritize the looms they need to visit without first going to every loom plus they may be able to ascertain if any additional tools maybe needed before heading to the loom.

**Data Accessibility Information**

Figure 2 shows the progression of communication ability or EDI (Electronic Data Interchange) over time. This interchange could be between machines within a plant, between plants in an enterprise, or more importantly between suppliers and customers.
In the early days of manufacturing and financial computer systems, almost all the data was manually entered into the computer. For example, orders from a customer were either phoned or faxed in and then keyed into several different systems (i.e., financial, manufacturing, distribution, etc.) since they often did not talk with one another. The advance of Ethernet made it possible for companies to perform Business-to-Business (B2B) transactions more easily. However, in the early 90s most of the data that was sent via email or hardwired intranet was still being keyed into the computer, because companies could not agree upon a standard format or protocol. Also, at that time the systems were often not flexible enough to allow the data to be imported directly into the underlying databases. This was further complicated by the various machinery manufacturers, which supplied their control/quality data in different formats and were unwilling to agree upon a standard format. Since the 1995 ITMA show, every system (i.e., ERP, MRP, management system, or machine control system) utilizes some SQL (Structure Query Language) compliant database. SQL has become the standard database language, which has made it easier to create and/or import data. Also in 2003, most of the control systems (e.g., BARCO, LoomData, Premier, etc.) utilize a local SQL database to store and manipulate data.

As companies began to collaborate with one another, both companies involved developed standard formats for flat data files. This often involved extensive programming for the supplier to import the data file into its SQL database as well as for the customer to generate the file that was often sent via email. However, this offered a large step in ease of communication since a standard format would be eventually determined along with the code to exchange the information. Lead times of the system were dramatically decreased owing to the time to enter in the enormous amount of information, and the errors associated with human data entry declined.

However, the files still needed to be emailed and processed by a person in the cooperating companies. During the mid to late 90’s the explosion of the Web made it possible for this information (i.e., data files) to be transferred and processed automatically via the Web. The next significant step came with the development and use of the Web for transfer of information. However, as new customers, machines, and/or systems became part of the equation, the effort of incorporating the information from the sources had to be repeated again and again.

**Figure 2.** Historical Evolution of Accessing/Processing Information
XML (eXtensible Markup Language) is a widely used standard from the World Wide Web Consortium (W3C) that facilitates the interchange of data between computer applications. XML is similar to the language used for Web pages, the HyperText Markup Language (HTML), in that both use markup codes (tags). Computer programs can automatically extract data from an XML document, using its associated DTD (Document Type Definition) as a guide. The Document Type Definition is a file that defines the elements and data structure contained in an XML document and is often sent along with the XML document. For example, when you save Microsoft Word as a Web page, it actually saves it as an XML document, which facilitates the saving of all of the font information and formatting which is generally ignored by Web browsers. However, the document can be imported back into word without loss of formatting.

**Future Directions**

Over the next few years, we feel the XML explosion of information sharing will take over most EDI utilized by companies and equipment manufactures. An example that was detailed at ITMA 2003 involved BARCO’s automatic on-loom inspection system, which detects warp and filling defects. It has the ability to generate defect maps and various quality reports when connected to BARCO’s QualiMaster™. The defect maps contains the quality of the fabric rolls in terms of defect types along with the location of those defects within the roll. The system has the ability to generate an XML document that describes these maps. A BARCO client can place these XML data files on their secure website and one of their client’s customers can download these XML files and utilize them directly to optimize their cutting systems. The ability to access and use the information by the customer to improve their cutting process has only been possible because of the information system of the weaver, the World Wide Web and XML as the data interchange format. XML has the ability to make the information interchange between various systems much easier. Almost all databases, ERP systems, and machine manufactures have begun to use XML to create and use information which has been driven by the fact that most of Microsoft’s products have the ability to produce XML documents. Most of the new SQL compliant databases can generate XML data documents that can be imported into other database systems extremely easy (i.e., the data and data structure is passed). See section on information systems, which describes how they utilize XML as their basis of information transfer.

**Control System/Machine Interface**

Like many of the areas, the control system interface closely follows the advancement of computing technology. As seen in Figure 3, the interfaces moved from a hard inflexible system to more flexible systems. Initially machines had basically on/off control, which was quite rigid. As sensing technology was added to these machines, the control system interface may have remained the on/off control, but the sensors were hardwired to stop the machine if certain conditions were met (i.e., an individual interfered with the path of a top feeder in an opening room, a delivery sliver ran out, or a broken end at weaving occurred, etc).
As more sensors were placed on the machine, a PLC had to be placed on the machine itself. Since the PLC was part of the machine, the systems interface would be the pendent connected to the PLC. These systems were a little more flexible since one had the ability to turn on and off certain sensors or setup actions when some event occurred. These systems evolved allowing additional sensors to be added to the PLC, but the interface was quite hard to use owing to the independent PLC programming language of each of the various machinery manufacturers.

However, the previous interface was local to the machine itself. As PCs became prevalent in the computing world, the interface evolved from the PLC pendent programming in a language to a text based monochrome interface linked to the machine’s PLC. The interface was easier to use than the previous version since a series of commands or possible a simple text menu was employed. Also the interface provided the ability to generate reports. However, these reports were fixed with what the control system company thought was important or it required you to pay them to modify them to fit your needs. Again the PC interface followed along with the progression of the data access using RS 232 ports as seen in Figure 1. As the systems progressed, one started to have the ability to monitor more than one machine (i.e. looms) from a centralized location via serial connections or Ethernet. However, the reports were fixed and could not be changed without the assistance of the system developers. A small advancement in the systems came when graphics were added to the programs for displaying graphs as well as increasing the interface’s usability and capability.

In the past four years, the systems interface has taken a very large leap in ease of use and in the flexibility of the system to fit various needs. In 1995, only a few of the machines used touch screens as their interface mechanism. In 2003, almost every machine system interface used touch screens as the basic means to interact with the machines. In order to utilize touch screens as the interface, the systems control has to use a windows-based interface. The advantage of using a windows based interface provides the user the ability to utilize different languages depending on the operator without any increase of cost. The language ability has the potential to lower off quality, lead times, etc owing to language barriers being removed. A windows-based interface is easier to use since most of the
commands are graphical as well as the outputs of the machinery can be displayed graphically.

Over 90% of those windows-based systems used a version of Microsoft Windows but that was only for the interface and not the underlying control system. All of these systems utilize a local SQL compliant database, which allows all of the information being generated by the machine to be stored and then sent up the chain to the information system via the Ethernet card in the PC. The database and windows-based systems provide the user with the flexibility to create/modify reports based on their needs without the need of system programmers. These systems are quite flexible in determining which information to collect, reports to generate, etc.

Many of the systems seen at the ITMA show (tExpert by Premier, Loomdata4, WeaveMaster™, QualiMaster™, and SpinMaster™ by BARCO, Uster™ QUANTUM Report) were extremely flexible in what they could monitor and report on. Users have the ability to design their reports with column/field names that were consistent with their organization. In another example in loom monitoring systems by both Loomdata and BARCO, the system has the ability to download the individual loom schedules from an ERP system and then can monitor in real time. If the company’s ERP system cannot schedule at the machine level, both systems offer the ability to download a set of jobs. The user can manually schedule the loom room using a graphical drop and drag procedure to schedule the looms. Figure 4 shows a screenshot of WeaveMaster™ where the black line represents the current status timeline while the blue and green blocks represent warp preparation and weaving schedules. The system allows you to manually move these jobs around while maintaining constraints on the system. Loomdata4 has a very similar system as seen in Figure 4. LoomData4™ offers a system with similar capabilities.

Figure 4. BARCO’s WeaveMaster™ Real Time Monitoring and Scheduling Module
Over the next few years, there will be a large growth in using mobile devices to interact with the machines and the information systems. Please see the Section on Data Enablers on wireless Ethernet for more information on the use of PDAs to interact with loom and spinning monitoring systems. These devices include PDAs, tablet PCs as well as web enabled mobile phones.

Parallel Human Interface

Since humans are a critical component of the manufacturing system, it is natural that advances in human interactions with the machinery paralleled advances in Control System Flexibility.

Operators have always had a method to signal a fixer when a spindle/loom/etc needed attention. Initially this was accomplished through mechanical “flags”. With the introduction of sensing technology by companies such as Uster and Barco, lights on frames/looms replaced the mechanical flags.

The next step in sensing technology resulted in LED Text-Based readouts on each machine with Keypad entry to control or change machine variables. This was quickly followed by Text-Based Graphics.

Each of these advancements required that operators/technicians have a different set of basic skills, often with less skills required for the operator and greater skills required for a technician.

At ITMA 2003, most of the informational interfaces used by operators/technicians had touch screens. Many of these screens used pictures and icon images to transmit the message. The advantage of such a system is that it is language neutral, including certain levels of literacy deprivation.

Information Systems

The maturation of ERP (Enterprise Resource Planning) was evident throughout ITMA 2003, with the key word being modularization. ERP systems are usually broken down into modules such as financials, sales, purchasing, inventory management, manufacturing, MRP or MRP II. The modules are designed to work seamlessly with the rest of the system and should provide a consistent user interface between them. These systems usually have extensive set up options that allow some flexibility in customizing their functionality to meet specific business needs. Figure 5 depicts the evolution of management systems over time.
Although most of the ERP systems have similar components, a variety of approaches were evident.

**DATATEX’s TIM™** (Textile Integrated Manufacturing) system has 21 software applications available throughout its 5 major areas of Enterprise Control: Planning, Manufacturing, Costing, Sales and Inventory & Purchasing. Information is readily transmitted using the World Wide Webb (WWW) coupled with XML language. Access to the system can be through Ethernet, PCs or PDAs (Portable Data Assistants). The system is sensitive enough to mine to an individual loom activity, which is, in reality, frequently a scarce resource. This particular system appears to be highly appropriate for batch or discrete processing, which is the direction many U.S. textile companies are pursuing.

**Schaeffer Productique™**, a French company that has been in existence for 20+ years, is another example of the state of textile ERPs that focus on the needs of SMEs (Small and Medium Enterprises). Its integrated business software SOLIN contains 5 components: Technical and Commercial Data Management, Sales, Purchases, Stocks (inventory) and Production & Subcontracting. It has 5 major fields of service:

- Solinfil Spinning
- Solintis Weaving, Knitting, Nonwovens
- Solinnob Dyeing/Printing/Printing/Finishing
- Solincop Home Textile Confection
- Solinnet Converting and Trading

The company has 150 site installations in 12 countries. The company is of interest because of the breadth of modules it contains and its concentration on SMEs.

Although **Premier Polytronics** of Coimbatore, India was listed in the ITMA catalogue as showing a software system for integrated production in the textile chain, its booth was in one of the spinning halls. Its heritage has been in data integration systems for spinning including fiber testing, yarn quality and in-process testing, and yarn clearing. More recently it has built a tEXPERT™ system that provides specialized ERP solutions for textiles. A window-based example of the system was available for demonstration. It was impossible to evaluate the veracity of the system at the show, but it was interesting to note the movement toward ERP systems is this part of the world.

Planning Systems as well as manufacturing technology are not restricted to country boundaries.

One of the most interesting Information Systems at the show was not officially identified in any of ITMA’s 2003 literature. A German company named “update” was co-located in the Loomdata both. In 1998 update marketed a software program named texware. The program has been installed in 120 companies in the German speaking area of Europe. Conceptually update emphasizes the necessity for information flow between the ERP system and the Supply Chain Management system. Their textile clients are weavers involved in a wide variety of markets including apparel fabrics, monofil and fireproof technical fabrics, and narrow seatbelt webbing as examples. Their apparel clients range from high fashion worsted men’s wear to casual sports wear. Although their company literature indicates a degree of interaction between their apparel customers and the retail segment, it is not clear how or if update currently serves the retail industry. However, they recognize that the retailers drive the Supply Chain and discussed the need to integrate retailing into their products. They plan to be at the next ATME show in Greenville. The directions they are taking are on target, and it will be interesting to review
their progress made. Figure 6 represents “update” view of an integrated ERP systems.

Figure 6. “update’s” Schematic of an Integrated ERP/Supply Chain System.

One of the most exciting things that is happening with information systems is the move towards web applications. For example, DataTex is releasing a new version called AB Solutions™, which is a Java2 Enterprise Web Application. The system decouples the application logic (e.g., ERP, MRP II, financial, etc) from the user interface. Therefore, the system provides the flexibility to completely customize the interface beyond just colors and fonts. Also, the system is accessible through any compliant Internet browser. Since the program utilizes the browser to provide the interface, a company no longer has to deploy/install the client applications on the production floor computers, office computers, etc. The application only has to be installed on the server and any client that has access to Internet uses a standard Web browser to access the computer information system. Therefore, there is a dramatic reduction of purchase, maintenance, updating and client alignment costs because any updates or changes only occur on the server. By using a standard Web interface with Java, these systems have the flexibility to utilize any operating system for the client and server as well as any SQL92 compliant database system.

AB Solutions™ is harnessing the power of the Internet to facilitate advance cooperation among partners, suppliers and customers with the concept of the “extended company.” To reach this objective it is necessary to have applications based on widely accepted standards at every level: the user interface (browser), Internet (TCP/IP and HTTP), programming language (J2EE), data exchange
(XML), and communication among different applications (Web Services). In this new scenario, applications of different companies that meet the standards can interact with each other, thus drastically improving the efficiency of the whole supply chain.

**Integrated Systems**

The Integrated Systems component of the show had the fewest exhibitors, and the degree of integration varied from vendor to vendor. Suppliers of software systems often differed significantly on their visions of the future. Companies with historical roots in sensing technology frequently guard against any attempt to share the data collected on an open platform. They believe there is little need to progress toward larger integrated information systems with easily accessible and transmittable information. However, there was an attempt for greater forward integration by those companies currently serving at least 2 or 3 segments of the supply chain. The movement in this direction was presented at the Gherzi booth.

Gherzi is a Swiss consulting company that has been involved with a project for the brand management company and retailer HUGO BOSS, a high-end marketer of fashion apparel. The corporation operates 550 stores on 6 continents through ownership and franchises, with headquarters in Metzingen, Germany.

To serve these stores with initial and replenishment fashions, the corporation has designed a warehouse to hold an inventory of finished fabrics that HUGO BOSS owns. The value of the inventory is said to be approximately $25 million U.S.

As shown in Figure 7, HUGO BOSS uses point-of-sale data at retail, plus finished fabric inventories, and work-in-progress data from apparel manufacturing operations, to develop a closed loop, integrated system that holds inventory at its raw material/low cost level, which is finished fabric. With its highly collaborative relationship between their fabric suppliers, apparel contractors, and their stores, this integrated system allows them to serve their retail markets at a high rate of efficiency and replenishment.
One can visualize a Supply Chain driven by Market Responsiveness and Demand.

If sales for any given SKU are brisk as illustrated by line “a”, a corporation could assign finished fabric in its inventory to apparel manufacturers for quick replenishment. They may also try to purchase additional finished fabric. Line “b” sales would use in-house inventory and line “c” would likely not be replenished, with any finished fabric available for use in other garment styles.
HUGO BOSS uses CAD technology extensively to create their first collections, followed by integrated systems for layout planning and technical outfitting for production facilities.

One of the keys to their growth in sales from $683 million Euro in 1998 to $1.0+ billion Euro in 2002 is their standardization concept for distribution used for selected specialty and monobrand shops.

In their own words:

“Following the initiation of B2B activities in 2001, HUGO BOSS moved forward with full implementation during the year under review. Direct intranet access enables our trading partners to place and trace warehouse orders directly and to retrieve current information on stocks and availability. Moreover, the e-sales activities serve to optimize processes and increase flexibility in the long term. This in turn reduces distribution costs and, most importantly, promotes customer loyalty and customer satisfaction.”

The above quote demonstrates the advancements made during the past few years as well as the systems developed at the retail level that are driving our businesses. Supply Chains are much more than cost reduction opportunities. **Embedded within the chains is the market knowledge that is essential in our global business model.**

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**Process Control in Wet Processing**

One of the main challenges facing process control engineers is the reduction of variable and operating costs while maintaining product quality. The implementation of advanced process control strategies is widely recognized as the most effective way to accomplish this objective, especially on existing production plants. The textile industry in the U.S. has a fairly large base of manufacturing facilities which are still being run by unsophisticated or primitive control schemes, so the implementation of advanced process control strategies offers an opportunity that could dramatically improve the productivity of the American textile industry.

Advanced process control strategies such as the use of neural networks, multivariable non-linear predictive control, robust control, knowledge-based systems and model predictive control are currently pursued by researchers and practitioners in the field of control engineering. However, after a careful analysis of ITMA 2003 exhibitors, it seems that very few of the wet processing equipment manufacturers and process control hardware and software providers for the textile industry are moving towards an immediate implementation of these novel concepts. Most of the existing control schemes for machinery in textile wet processing can be categorized between levels two and three of the process control integration hierarchy as shown in the figure below.
Only few companies offer solutions that cover the five levels of process control integration from planning and scheduling (ERP systems) to individual machine control. However, most of these solutions require that the majority of the process control hardware and software will be developed and manufactured by a single source. The main barrier to reach higher levels of process integration is the lack of compatibility of communication protocols and the resistance of some traditional textile equipment manufacturers to implement standard and open process control protocols such as OPC.

Although the implementation of advanced control strategies is not foreseen in the immediate future, it is apparent that the textile industry is slowly moving toward modular machines and systems. The dedicated systems still prevalent today are gradually being superceded by a modular approach that involves standard units, distributed automation concepts and an increasing replacement of mechanical components by electronic and software alternatives.

New Process Control Equipment

Rather than present an inventory of the hundreds of existing products from the process control vendors exhibiting at ITMA 2003, the authors would like to focus the discussion on new technologies and their implications on the productivity of wet processing operations.

Programmable Logic Computers

Arguably the most popular technology for plant automation has been Programmable Logic Controllers, otherwise known as PLC’s. These units offer high-quality input/output electronics as well as excellent real time monitoring capabilities and are specifically designed for the shop-floor environment.

PLC is a well established technology and only minor improvements were noted in the new pieces of equipment available at ITMA 2003. The main focus of improvement was an increase in the flexibility, scalability and connectivity of PLCs with supervisory and monitoring control systems. Most of the PLCs at the exhibition allowed additional connectivity via TCP/IP in addition to the traditional Profibus, Modbus and serial interfaces. Lately, there has been a great interest in the use of the Profinet protocols which allows better interface communications between PLCs and supervisory, planning and scheduling systems.
Traditional PLCs used to be directly connected to the machinery’s actuators and sensors, and its modular architecture made it easy to combine different types of I/O interfaces. Following its original purpose to substitute hard-wired logic circuits, PLCs used to be programmed using an external detachable programming unit. Once programmed PLCs used to work as stand-alone systems. However, complex automation systems are currently built using information intelligent fieldbuses, so the main advantage of the traditional PLC to combine I/O interfaces and the process computer in one modular unit has lost its impact. Nowadays, in most process control applications traditional PLCs are currently reduced to a CPU with some communication and field bus interface modules.

Due to the advances in PC microprocessors and fieldbuses, integrating the functionality of PLCs into PC based controllers was the next obvious step in process control.

**PC Based Control Systems**

The continuous development of the PC hardware market, which offers compatibility between almost all manufacturers, has opened a possibility to provide high performance process control systems. Most of these PC based control systems run on Windows CE, a new version of Windows specifically targeted at embedded systems.

There are three main innovations in CE that make it suitable for process control work: CE does not need a hard-disk but uses instead more reliable storage media such as flash memory cards or memory chips, making the system more suitable for use in an industrial environment. CE can be turned off and then back on immediately, without any start-up delays, and finally CE is a stand alone operating system providing rugged, Windows compatible functions, using hardware that can be fitted into a control-panel.

Another advantage of PC based controllers is that most of them use Microsoft Visual Basic (“VB”) to create process control systems and interfaces. VB is a well-established programming language that can provide satisfactory performance, 1000 scans per second, on Intel Pentium-class processors. This level is performance is achieved by using optimization tools of the Microsoft VB compiler. The use of standard PC software tools allows process diagrams to be created using conventional packages such as MS Visio. PC based controllers also follow industry open standards such as ODBC, COM, DCOM, ADO and ActiveX facilitating communication with supervisory and monitoring systems.

Perhaps the most important advantage PC based controllers is that each control unit can eventually become a web site by itself allowing remote network access and interrogation via TCP/IP without the need for a host system.

One of the main players on PC based control systems is ADAPTIVE CONTROLS, a company based in West Yorkshire England. Adaptive control offers solutions for the entire textile industry, but lately has specialized in the dyeing and finishing sectors creating particular control systems for jet, beam, and package dyeing operations.
Figure 10. Schematics of ADAPTIVE CONTROLS PC Based control system for jet machine. (COURTESY OF ADAPTIVE CONTROLS, LTD)

Figure 11. Schematics of ADAPTIVE CONTROLS PC Based control system for rotary machine. (Courtesy of ADAPTIVE CONTROLS, LTD)

In addition to its traditional line of dedicated controllers and PLCs, BARCO is also in the market of PC based controllers. BARCO is recognized as one of the international leaders in the supply of automation concepts for the textile dyeing and finishing industry. BARCO SEDO products have been in the market for over 20
years and are currently used in most dye houses worldwide.

BARCO PC based controller is the Sedomat 2500 which combines a friendly color touch screen user interface, TCP/IP network integration, web server technology for remote control, and a USB standard interface. SEDOMAT 2500 runs on Windows CE and allows for a seamless connection to BARCO centralized control system SEDOMASTER. The SEDOMAT 2500 also has a Profibus DP interface to link remote I/O modules and uses OPC architecture that allows a seamless integration with supervisory systems.

**Figure 12.** BARCO SEDOMAT 2500 PC based controller for dyeing and finishing applications. (Courtesy of BARCO SEDOMAT)

TERMOELECTTRONICA, S.P.A. offers PCx which is a PC based controller optimized for operation in hard environmental conditions such as high humidity, mechanical vibrations and stresses, dirt and dust. The PCx architecture is based on a new generation processor requiring no ventilation (fanless) and a Flash and Disk on Chip solid state memories. In addition, PCx has dedicated interfaces to PLCs and I/O boards. PCx runs on Windows XP Embedded. The PCx is Termoeletttronica standard platform for advanced automation and control in dyeing and finishing machines as well as dosing and distribution.
SIEMENS has been one the most recognizable names in the area of automation. Although it continues to produce dedicated controllers and PLCs for the textile industry, it is also using PC technology for some process control applications.

Siemens SIMATIC Panel PC 670 and PC 680 run on Windows CE and are compatible with existing PLCs via a PROFIBUS interface. The SIMATIC PC 680 is especially designed for highly aggressive industrial environments offering protection against oscillating loads of 1g and up to 5g on shock load (impact) conditions. The SIMATIC has PCI and ISA expansion slots. The PC680 runs on Intel Celeron and Pentium IV processors and uses a 2.5” hard drive up to 20 GB.

Figure 13. PCx controller (Courtesy of TERMOELLETRONICA)

Figure 14. Front, rear and lateral views of the SIEMENS SIMATIC PC 680 (Courtesy of SIEMENS)
While PC based process control is definitely an emerging technology that offers compatibility with other Windows based systems it also faces some drawbacks in areas such as real time data acquisition, short life-time spans for equipment and software and increasing licensing fees. PC based control systems are easier to implement than PLCs, but there is a significant difference in performance in the area of real time data acquisition. Although some improvements have been achieved lately, the fastest resolution time achieved for PC based controllers is in the order of 50 microseconds compared to 1-2 microseconds on standard PLCs. This may not be a barrier for conventional applications, but when a particular process requires close monitoring, delay times in data acquisition can create control problems that can escalate and create process instability.

In addition, the continuous improvement of PC hardware technology as well as the continuous development of new versions of MS Windows software requires that some of the PCs used for process control be upgraded or replaced more often than expected. PCs become obsolete more frequently than industrial PLCs. In addition, each PC based controller requires the purchase of licenses for Windows CE or XP.

**Wireless Process Control**

The use of a PC open architecture and a Windows based operating systems allows for the implementation of wireless networks by using off the shelf components. Several manufacturers provide wireless devices that can be used as mobile control and supervision centers. Handheld PDAs and tabletPC are commonly used in these roles.

![Figure 15. Tablet PC equipped with wireless communication used as a mobile control and supervision center. (Courtesy of Setex and Advantech)](image)

Another advantage of using PC open architecture and TCP/IP protocols is the ability for most vendors to connect directly into the controllers. This level of connectivity allows the vendors to perform routine maintenance and software upgrades and reduces the response time for service requests as diagnostic tests can be performed prior to the visit of the technical service representative. In addition, process control
and production engineers can easily monitor the processes from almost any computer equipped with an internet connection. This flexibility in communications also opens a new field regarding to communication security.

While the use of MS Windows software has brought many benefits to the technical computing community, the presence of licenses fees, and issues regarding computer stability and robustness as well as some restrictions in code development have motivated the development of alternative and open operating systems such as Linux.

**Linux Based Controllers**

ELIAR A.S., a Turkish company based in Istanbul, offers a novel alternative to the use of Windows based controllers by using Linux as an operating system. Eliar TB6500 was the first embedded Linux based industrial batch process controller. Newer models include Iris 11 and Iris 17. Iris 17 is a batch controller designed and developed for the full automation of textile dyeing machines which require limited input/output and functions. These Linux Based controllers have Open PLC (IEC61131-3 standard) language support, which enables users and textile machine manufacturers to write their own specific functions and process commands according to the machine properties and requirements. Since Linux is an open and free operating system there are no fees associated with the use of this technology. In addition, Linux operating system has proven to be more stable and reliable than Windows based operating systems.

With all the advantages of having a free and open operating system it was expected that Linux could become the standard operating system for the majority of process control applications. However since most of the supervisory and monitoring applications as well as the planning and scheduling programs are currently running on Windows based computers, the fate of Linux is influenced by the large market share of Microsoft Windows based software.

![Image](image.png)

**Figure 16.** ELIAR TB6500, the first Linux embedded controller designed for dyeing and finishing applications.

**Fuzzy Logic Controllers**

Fuzzy logic is an approach to computing that tries to bring reason to the vagueness usually found in human behavior or the unclear boundaries in physical processes. Traditional Boolean logic is based on a series of YES or NO answers, but fuzzy logic offers degrees of partial truth to a particular equation for a more human approach. Fuzzy logic was originated at U.C. Berkeley in 1960’s and the use of...
fuzzy logic in process control is currently increasing. While fuzzy logic is not needed for every application, it can prove helpful in hard to control situations, which may be susceptible to sudden process upsets or disturbances such as the dyeing and finishing operations.

FONG National Engineering Company introduced a stand alone microprocessor based controller for dyeing and finishing applications with fuzzy intelligence. The FC 38 has an embedded fuzzy control module in the controller that monitors the environment during the dyeing process and comes up with the most optimum parameters for temperature control. This type of optimization cannot be achieved with conventional PID controllers. Some of the advantages of introducing fuzzy logic in temperature control applications are the reduction of overshoots (lower consumption of steam and cooling water) and a steadier and reproducible behavior that can result in better color shade along the fabrics and reduction of the wrinkles and crease marks created by temperature fluctuations.

Figure 17. FONG’s FC38. The first stand alone controller incorporating fuzzy logic for dyeing and finishing applications (Courtesy of FONG’s)

Although fuzzy logic can be easily implemented using software code in existing PLCs and PC based controllers, the FC38 from FONG’s was the first stand-alone controller that implemented the fuzzy logic concept.

Complete Automation Solutions

Achieving higher levels in process control integration and therefore higher productivity requires the use of complete automation solutions with compatible communication protocols that allow seamless interfaces between the controllers in the shop floor and the planning and scheduling systems. Only this level of process control sophistication makes possible the dynamic optimization of the resources available.

Although recognized firms in the general area of automation such as ABB, Siemens, Allen Bradley and Telemecanique offer complete automation solutions, the products offered by traditional textile equipment manufacturers such as BARCO, SETEX, MAHLO AND SCHOLL-THEN appear to have a competitive advantage. This is not surprising as these manufacturers have for a long time provided controllers for textile dyeing and finishing equipment. It is widely recognized that the most challenging steps in implementing higher levels of integration occur between the machine controllers and the supervisory and
monitoring systems due to the myriad of process control equipment used in traditional textile factories.

Innovative products in the area of complete automation solutions include Barco’s SEDOMASTER which operates as a central management system for the dyeing and finishing industry. SEDOMASTER is a Windows based solution designed to manage the dye house or an entire textile finishing plant. SEDOMASTER provides an integrated solution, allowing operators as well as executives to manage recipes and processes. SEDOMASTER also provides all related interfaces to other production and auxiliary systems such as chemical dispensing and recipe management. The resulting optimization of all machinery including dyeing, washing, bleaching, stenter, dryer, calander, etc. minimizes processing and reprocessing time and cost.

SEDOMASTER can be linked to the BARCO SEDO ColorMaster color matching and recipe management system and to the DATACOLOR recipe system. Batches are entered in SEDOMASTER and automatically transferred to the recipe system which calculates the corresponding production recipe (dyestuffs and chemicals) and transfers it back to SEDOMASTER. The recipe can then be shown on the weighing station or sent to an automatic dispensing station. In addition, the recipe system can optimize the production process (temperature, speed, gradient etc.) corresponding to the batch data and the calculated recipe. SEDOMASTER uses this information to create an optimized (cost and quality) production process that is downloaded directed into the machine controller.

Figure 18. Schematic for the operation of SEDOMASTER, a central management system for the dyeing and finishing industry (Courtesy of BARCO)

In summary, dedicated microprocessor based controllers and PLCs continue to be the most common mechanisms to provide process control in textile wet processing machinery. An increase in the controllers’ flexibility and communication capabilities was noted in the new PLCs at the ITMA 2003 show. PC
based process controllers are increasing their share in the market due to their compatibility and relatively easy operation and programming. In addition mechanical devices used in process control such as switches, lights and buttons are being replaced by software and electronic components.

The introduction of novel process control strategies and the integration of the machine controllers with the planning and scheduling systems can dramatically improve the productivity of textile wet processing. The biggest obstacle to obtain this objective is the lack of an open and standard communication protocol (such as OPC) that could allow the integration of the myriad of controllers present in a textile production unit with Windows based supervisory and monitoring systems.

The implementation of advanced process control strategies in the chemical process industries has brought unimaginable savings in raw materials and energy as well as a higher degree of process stability, reliability and product quality. It will not be a surprise if the same level of dramatic improvements can be achieved in the textile industry once these technologies are incorporated.