AUTOMATION IN TEXTILE FINISHING

Foreword

The textile industry is characterized by a considerable fragmentation of the production cycle into a number of segments specialised in the processing of different fibres/yarns; even the single steps are often considerably fragmented, which entails the need for them to be accurately organised in order to guarantee good final results. The first steps of the textile production cycle are less fragmented but fragmentation unquestionably increases during the finishing stage, as a result of the large variety of processes required by the market. Modern automation technologies based on electronics, programmability and smart systems show great potential for textile applications and currently aim to the achievement of crucial objectives such as flexibility and quality, according to three main evolution paths:

1) the standardisation of components
2) the compatibility of systems
3) the popularity of personal computers.

The standardisation of components takes place thanks to the concentration of automation technologies in some basic types of operations (processes) which must be carried out by the machine. The machine is characterised by a system made of inputs and outputs. Inputs are sensors which transform the physical variables of the system into electrical values which can be read and processed by an electronic unit. Outputs are the actuators controlling the machine and consequently the process (motors, solenoid valves, thermoresistors).

Any process can generally refer to this operating scheme and can be controlled by making inputs operating in relation to the state of the output and following a preset sequence of times. The computer, by means of the appropriate software, supplies the logical links between inputs and outputs and controls the right process sequence.

Through its gradual introduction, automation has affected:

1. machines: the immediate objective was the reduction and simplification of the operator's tasks;
2. processes: the subsequent evolution stage has provided the links between the different production steps with the automatic control of the mill, leaving the operator with only control and supervision tasks. The full integration of the different production areas (inventory control systems, preparation of dyes and auxiliaries, dyeing equipment, material storage, etc) and /or services such as planning, laboratory, design pattern development, technological planning of cycles and production still needs to be addressed. The most advanced integration solutions available today are mainly production cells.

The main difference between automated systems essentially lies in the quantity of variables controlled. Here are the finishing segments most affected by technological development:

1. **colour analysis**
2. **process control**
3. **production control systems**
4. **colour kitchen**
5. **automated inventory control systems**
6. **transport and robotised systems**
7. **machine control systems**

Colour analysis and control

It is worth remembering that in the past the assessment of colour reproduction was exclusively entrusted to the ability and to the experience of the eye of highly skilled operators working on the colour kitchen, whose judgement, however, could be influenced by a number of physical, physiological and psychological restrictions. The success and the development of electronics have deeply transformed the colour control task thanks to the introduction of new measuring instruments, which have allowed definitely scientific and objective assessment.

All the systems currently available on the market have basically the same fundamental structure and differ only in their performance and in the algorithms adopted for colour analysis. These systems generally feature:

1. a spectrophotometer, which measures the different spectral components of the sample analysed. Today the measurement is carried out by means of a xenon flash, a prism separating the chromatic components and a CCD sensor (of the type used for modern solid-state television cameras that have only a single row of light-sensitive elements or pixels), which reads the intensity of all the components simultaneously;
2. a standard computer, connected to a spectrophotometer like a simple peripheral unit.

The software carries out the processes and defines the functions of the system. It represents an interesting field of competition and makes the real difference between the various systems.
In brief, the software includes the following functions:

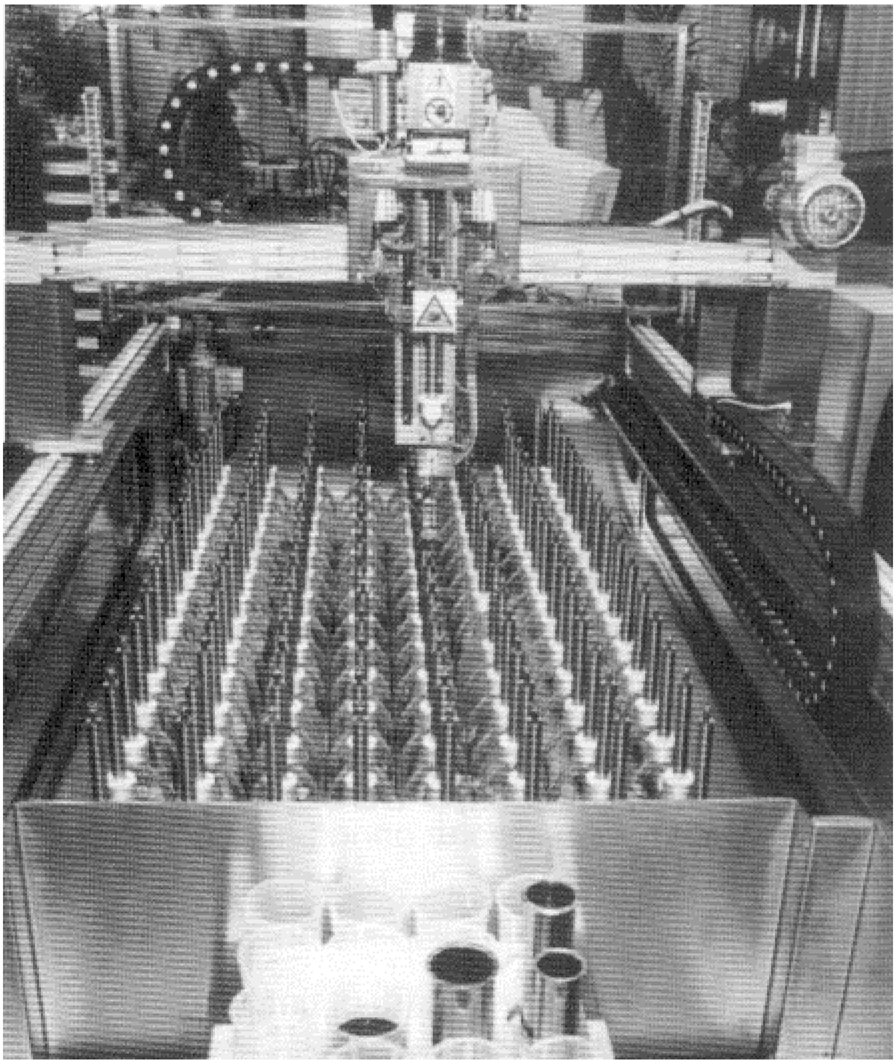
- algorithms for colour analysis (processing of the data measured by the spectrophotometer to recognise the colorimetric features);
- preparation of recipes, i.e. the combination of several base dyestuffs to obtain the desired colour by accurately mixing and distributing them; the colour to be matched is suggested to the computer by reading the reference sample with the spectrophotometer;
- assessment of the colour differences, i.e. the assessment of the distance between the colours of the two samples in the colour table, expressed in different systems of coordinates;
- correction of the recipes, i.e. the analysis of the difference between the colour obtained with the machine and the reference colour, and the calculation of dye distributions to improve the dyeing result;
- control and storage of references and recipes for future retrieval;
- control and storage of dyestuffs and textile substrates;
- different types of algorithms to match the colour table to visual assessment and to the type of source used (so that the differences that the human eye has perceived as matching can generate assessments of the same degree);
- selection of the recipe which better matches the sample, the costs and fastness;
- other valuable functions;

Automatic devices for the preparation of recipes are now considered crucial for all well-organised and efficient dyeing mills.

BENEFITS
Repeatability of procedures
Reduction of sampling times
Reduction of sampling costs
Reduction of dyestuff consumption
Possibility to assess the dyeing efficiency
Impartiality of the assessment
Better control of colour archives
Cost control
Quality improvement

LIMITS
Integration problems
Need for special training
Needs for organisational changes
Need for preparation steps

There are really many reasons justifying the investments in automation which can be carried out at different levels and consequently having different costs; it is worth remembering that even the most sophisticated automated systems applied to any production cycle, turn out to be useless if the information coming from the laboratory is scarcely reliable or even incorrect.
To obtain reliable indications, the laboratory and the production units must first of all be equipped with machines and tools working on the basis of the same operating concept (i.e. the laboratory must be in a condition to reproduce the same operating conditions as during the production process).
With reference to the above-mentioned considerations, it is worth mentioning that manufacturers of colour matching systems have studied the reproducibility of measures, based on very precise and repeatable calibrating procedures. **The dyestuffs must be accurately dosed both in the laboratory and in the dyehouse**. As far as this latter is concerned, no real innovations have been introduced, due also to the high technological level reached by modern automatic colour kitchens; the only real innovations have generated an uninterrupted improvement of the dosing techniques for dyestuffs in different forms (liquid, powder, paste), leading to very accurate results also on large quantities.
The multi-pipette volumetric dosing system is meeting with success in modern automated dyeing laboratories since it eliminates all the residual limits of the standard single-pipette volumetric system.



Picture 183 – Multi-pipette sampling system

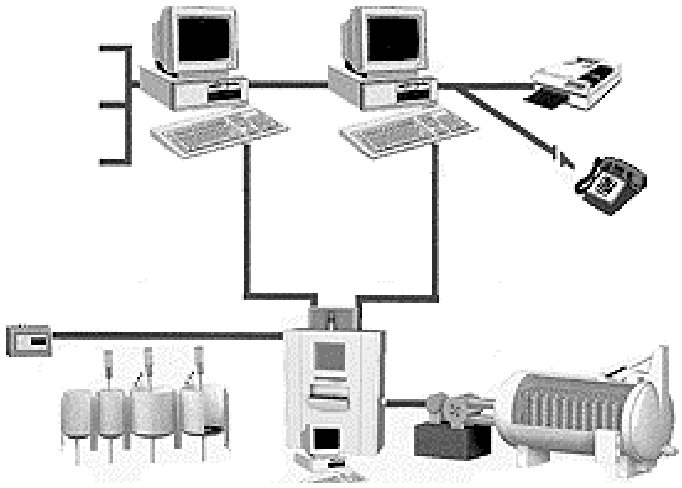
Here are the main benefits ensured by multi-pipette systems:

1. the elimination of intermediate pipette washing when changing the dye or the substrate, which considerably reduces the operating times necessary for each single dosing procedure and, at the same time, up to a 40/50% increase in productivity (compared to single-pipette systems).
2. the thorough elimination of any residual contamination risk, which could occur in particular with some products and dyes even after accurate washing of the pipette.

Very important also are the benefits deriving from the use of special pipettes studied for the particular properties of some products (viscosity, precision, speed) which give excellent technical results. Another important issue is also represented by the application of a gravimetric system for dosing testing, which completely eliminates any residual doubt concerning the quantities delivered during each single delivery of the pipettes. Operating data are registered by means of a printer, while an automatic self-calibrating system guarantees a continuous check-up of each single pipette.

Process controllers

While process control technology is not as specific as vision technology, it encompasses all manufacturing sectors.



The process controllers relevant to textile manufacturing are basic information-electronic systems that, installed on the machine, control certain fundamental parameters relating to the production process carried out on the machine itself. Essentially, they can be broken down into 4 categories according to the technology of the controller involved, which is itself dependent upon the type of process being controlled.

1. **Cycle programmers**: these are present on many dyeing machines and they are based on the general principle of activating outputs according to inputs. But their actual functioning is more specific: they are pre-programmed to manage a sequential cycle of operations. This facilitates programming, because the only thing that has to be done is determine the sequence of the steps in the cycle and the conditions required for the passage from one step to the next (the reaching of a certain temperature, the expiry of a set time, the arrival of a go-ahead signal, etc.). There exist two types of cycle programmer: one based on a microprocessor whose hardware and software remains the property of the supplier, and one based on a PC- or PLC-formatted architecture, which offers all the advantages of standard hardware and flexible software.
2. **PC-driven Programmable Logical Controllers (PLCs)**: these systems are equipped to receive logical information (from switch or pushbutton contacts, limit switches, photocells, any kind of ON/OFF sensor) and to activate logical outputs (electric drives, relay contacts, etc.) A controller checks continuously the status of inputs (openings/closures, presence/absence of electrical current), and according to the configuration of the inputs, activates its own outputs (activated/deactivated, ON/OFF, command presence/absence). The logical correlation between input status and the output status consequently imposed is determined when programming the system. Thus, the PLC can be regarded as a completely general purpose tool, capable of carrying out, when duly programmed by the user, the most diverse functions. In practice, PLCs are used to resolve all those problems relating to automation and sequence management that used to be resolved using electrical systems and relay logics. They feature on practically all the systems used, in textile finishing, for operations such as washing, mercerisation, dyeing, drying, calendering, raising, pad-batching and steaming.

3. **Numerical Controls**: these are electronic systems, specifically designed to control the positioning of a number of moving organs (e.g., robot axes). Using special languages, they programme the sequences of the positions of the various axes, each of which is controlled through measurement of the position of the organ. This measurement is carried out by high precision transducers (encoders, resolvers, optical rulers), which transmit to the numerical control a number (hence the name of the system) which represents that position.
4. **Special programmers**, developed specifically to carry out dedicated functions. These programmers are designed with and for the machine, in such a way that input and output signals and processing capacity are kept to the absolute minimum. In order to reduce costs, size and maintenance, they are often engineered in the form of single electronic cards.

The four systems described above are can be integrated with one another, and are often used together.

BENEFITS
Better process quality
Reduction of errors
Greater production flexibility
Rationalisation of the cycle according to scientific criteria
Rapid personnel training
Greater familiarity with production characteristics
Scope for integration with other company information systems
Repeatability of procedures
End quality no longer dependent upon the skill and experience of staff

LIMITS
Need for organisational changes
Difficulty personalising the system to specific requirements
Difficulty interfacing with different IT products
Need for assistance and maintenance

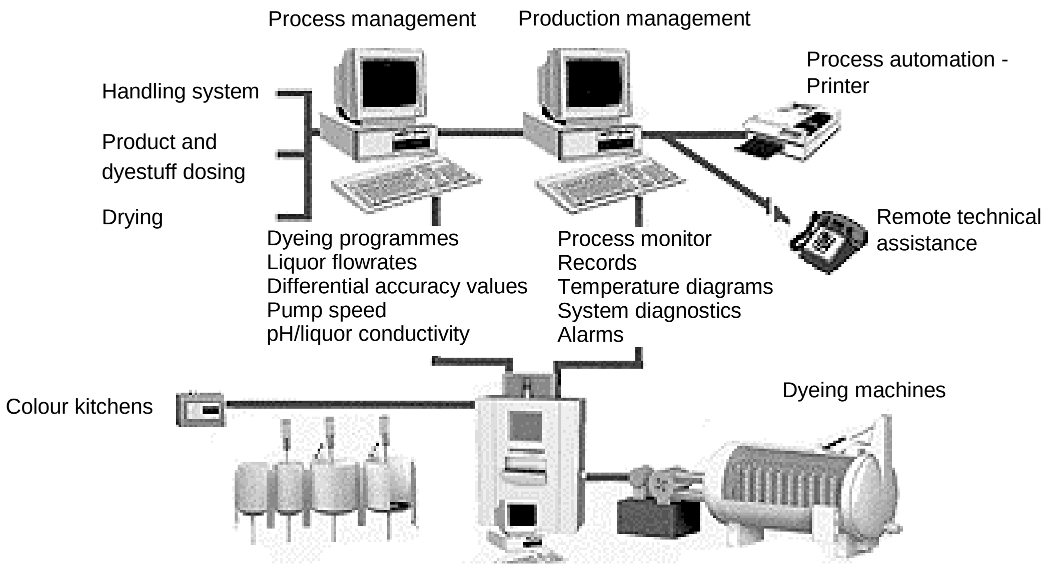
PRODUCTION MANAGEMENT SYSTEMS

The presence, in factories, of highly intelligent, local control systems has favoured the development of production management systems. Nearly all process controller producers also offer surveillance systems that centralise data relating to checks carried out on the machine and allow various levels of interaction.

There is now a very wide range of production management software functions available, and new developments are emerging all the time in various areas as a result of greater contact between software designers and users in the textile sector. These areas include:

- production planning
- planning of production start-up (availability, requirements in terms of human resources and machines, etc.)
- management of dyeing and finishing cycles
- plant and single machine surveillance, remote acquisition and saving of key physical parameters, log record of alarms
- plant and machine synoptic alarms (sometimes interactive)
- records of orders and work carried out
- recipe and cycle sequence management

- management of dyestuffs and auxiliaries warehouse
- s tatistical analysis of production
- quality control-based classifications
- tracking of single batches, i.e., the keeping of records of the different dyeing and finishing stages so as to make it possible in the future, in the event of disputes or problems, to trace the history of a piece
- link-ups with ERP systems, for the transmission of data relating to technical operations of interest to the accounts department.



Picture 184 - Example of an open, modular system for the remote control of the dyeing room or dyehouse, which allows the installation of different modules on the desired hardware platforms; the various surveillance modules can be positioned at different points within the system.

The application of information technology to production in the textile sector is similar, in many regards, to its application in most other manufacturing sectors. In particular:

- information technology is taken out of the IT centre, and distributed throughout the mill, making it possible to present/access data wherever they are needed or generated;
- purely administrative functions are supported, more and more, by out-and-out automation functions: management and processing of organisational-type data, but also technological data relating to production;
- batch processes (data processing operations carried out by the computer at the end of which one obtains: balance sheets, production plans, warehouse status, etc.) are replaced by real-time applications, which make it possible, through one of the terminals linked up with the computer, to access and update records immediately;
- there is a growing need to integrate the processing of information relating to areas that are distinct from, but connected with, one another: design, technological definition of processes, machine preparation, planning of resources, etc.

Textile companies want the adoption of IT systems in the production environment to generate a greater and greater rationalisation of management, and to reduce errors and waste. The requirements of a textile company, as regards its information system, can be broken down into three areas:

1. **Company management**: at this level, information systems are needed for the working out of production plans, the checking of results and the working out of sales and cost plans.

2. **Function management**: here, they are required to respond to the need to determine the production plan and flow. In particular, they help in the processing of orders, converting them into processing instructions for individual departments, stages or machines. They make it possible to optimise batches on the basis of resources and technological parameters, even simulating the production chain so as to optimise production speeds and balance workloads among machines.
3. **Process management**: here, they serve to tune the numerous technical regulation and programming procedures that are involved in the production process. In this stage, information systems make it possible to gather all the basic data needed for control and function planning activities.

BENEFITS
Integration of different areas (resource planning, designing, recipe preparation, machine programming, cost control)
Better customer service in terms of order status and delivery times (shorter)
Reduction of errors
Increased company flexibility
Greater control over the company's overall activity
Reduction of stocks
Reduction of downtimes
Process repeatability

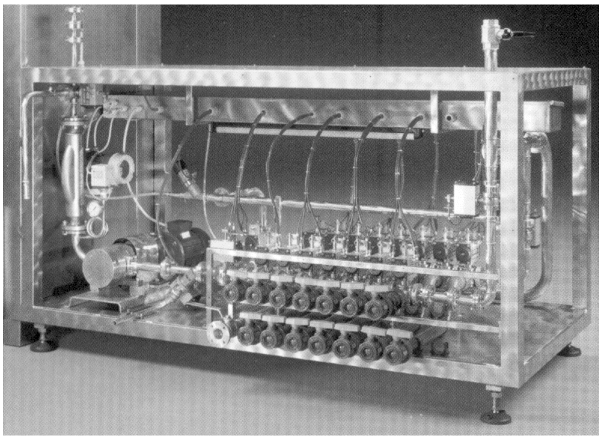
LIMITS
Modification of the *modus operandi* (which results in the need to standardise procedures and train staff)
Standardisation problems (due to control systems that are often incompatible with one another)
Poor product customisation

AUTOMATED COLOUR KITCHENS

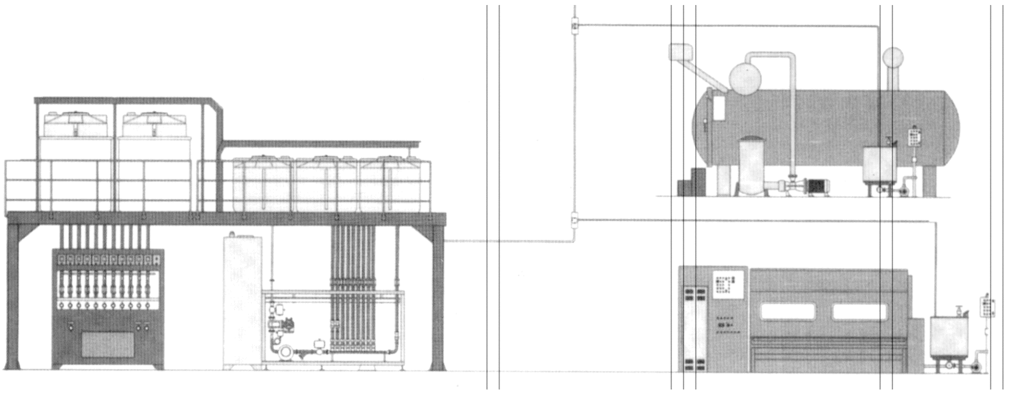
The problems raised by colour kitchen departments in a dyeing mill are not the same as those raised by the colour kitchen departments in a printing mill, and thus the automation solutions developed for each differ considerably:

1. In **printing mills**, where only viscous fluids (pastes) or auxiliary solutions are used, there are two fundamental requirements: first, to sample the N number of colours per design pattern in the program, and second, rapidly to supply each printing unit with the relevant coloured pastes, in the appropriate quantities: clearly, many samples and products are involved, as are very short execution times. For at least a decade now, systems have been in operation that are able to meet sampling requirements, and that are often used together with other systems that dose print pastes both for sampling and for production. Dosing systems are linked up with a series of containers (which vary considerably in number), each of which is constantly filled with a colour or with a print paste and/or auxiliaries. These containers are connected to the pneumatic or electrical pumps that keep the colours moving and deliver the product to the dosing point. Dosing is controlled by dedicated controllers or PLCs linked up with PCs, which look after recipe preparation and production management. In certain circumstances, the PCs can be linked with a spectrophotometer and with the company management unit.

2. In **dyeing mills**, products used in the preparation of recipes can be in liquid or powder form (auxiliaries or dyestuffs) and colour kitchens usually have four dosing systems with distinct functions:
   a) Dosing of liquid auxiliaries. Liquid products are measured using volumetric lire counters, solid-state gauges or scales. The system doses the product and delivers it to the machine via a single pipe or through a distributor (one pipe per machine).

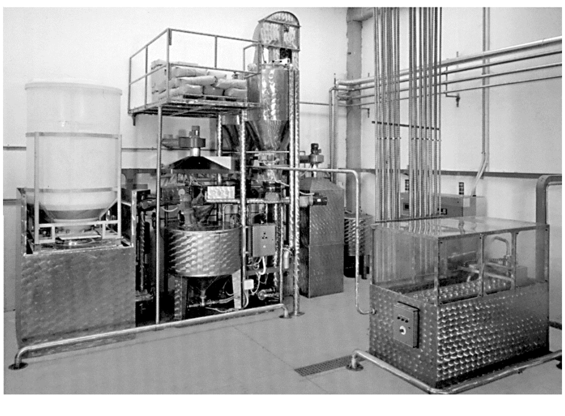


Picture 185 - Liquid product dosing station



Picture 186 - Diagram of a liquid product dosing station

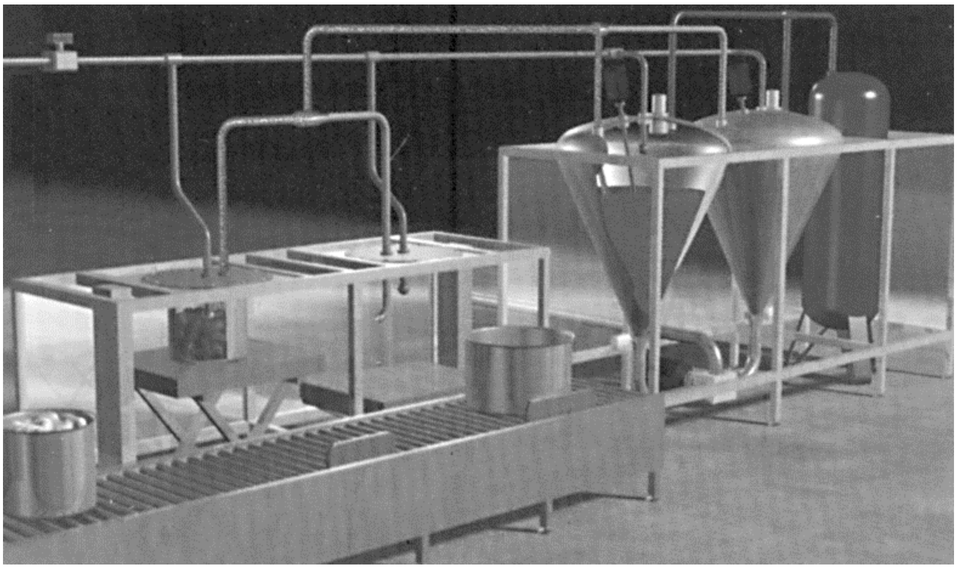
   b) Dosing and dissolving of solid auxiliaries (salts). Salts are dissolved in small quantities of water (ratio <1:1) and conveyed through a single pipe or distributor to the relevant machines.



Picture 187 - Powder product dosing system detail of the distributor

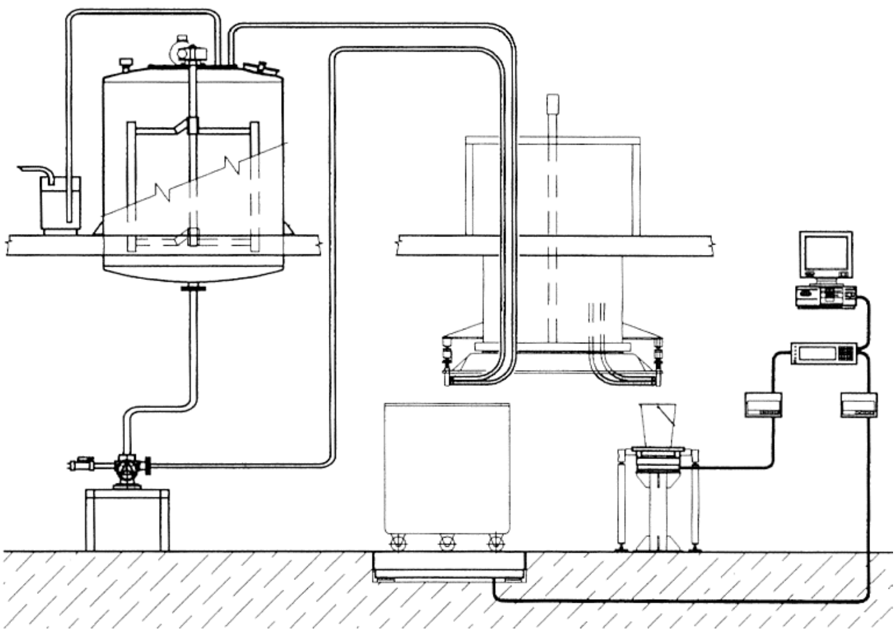
Picture 188 - Powder product dosing,

c) Dosing of powdered dyestuffs. The dyestuff is transferred through worms to containers on scales. In dyeing, the use of water-soluble bags is common. These bags are closed after dosing and then immersed in the tank, which is located on the machine. The dosing system is often used together with a traditional dissolving system – this kind of system has a mixer or recirculating pump and the powder is conveyed to the mixer by robot – or a new generation dissolving system (in which the transfer and dilution of the powders occurs by suction, i.e., thanks to the vacuum created in the dilution container).



Picture 189 - A dosing system for powdered dyestuffs. In the foreground, the suction and washing station, in the background the dilution station.

d) Dosing of liquid dyestuffs. This is done using machines like those described in point a) or, when greater precision is required, using the dosing technology employed in printing mills.



Picture 190 - Diagram of a dosing system used in printing mills

The complexity of truly automated colour kitchens is a result, above all, of the different forms the product can take; as a result of which it is difficult to unify the systems. Weighing, whether of liquids and viscous pastes, or of powders (providing these are homogeneous and non hygroscopic), does not really present any particular problems that need to be solved, but the contemporaneous presentation for processing of products in different forms makes it necessary to have multiple dosing and weighing systems.
In practice, colour kitchens have been created that have dosing systems suitable only for dyestuffs and auxiliaries available in the liquid state, and that weigh the others semi-automatically (or vice versa).
It is important to develop dosing systems that take into account the consumption levels and the contemporaneous demands of the various machines.
The automated kitchen management programs available are generally concerned solely with the transmitting of information needed for weighing, dissolving and conveying to storage tanks, while the timer-controlled feeding and running of the production machines is managed directly either by process controllers located on the machines themselves and possibly linked up with a central system for the storing, management and conveying to the machines of cycle programs (integrated systems), or by operators (semi-automatic systems). Clearly, logical and timely programming of the two stages (preparation of recipes and their use in the dyeing rooms) also needs to be coordinated with warehouse availability (fabrics and products) and central programming.
There already exist fairly simple automated systems for these operations, but here too, when it comes to all the various connections, one comes up against the interfacing problems mentioned in the chapter on recipe preparation systems. In short, it has become essential, as soon as possible, to achieve unification of processor interfaces.

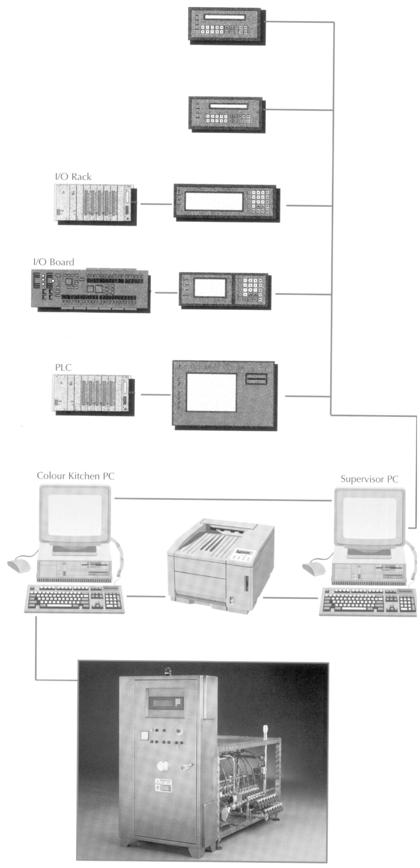
BENEFITS
Reduction of errors thanks to automatic dosing of products
Reduction of waste and downtimes
Rapid dosing
Space savings, thanks to the compactness of the systems
Repeatability of procedures
Better conservation of products in closed tanks and elimination of contamination through contact with the external environment
Improved worker and environmental safety (special exhalation abatement systems)
Reduction of labour due to the elimination of manual operations
Conformity with manual load handling regulations
More rational organisation of labour, greater integration of operational stages and higher engineering level of the dyeing process

LIMITS
Modification of the *modus operandi*
Difficult integration with production methods
Systems not always sufficiently reliable
Difficulty interfacing with recipe preparation systems.

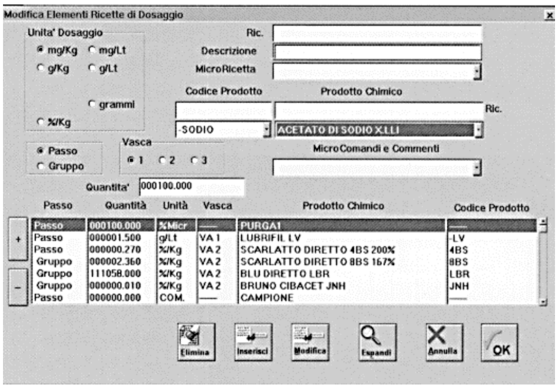
One of the most important technical characteristics that an automatic dosing system must have is, without doubt, the capacity to dose within certain limits. A dosing machine's operating limits are also the safety limits within which it must work; dosing requests at the limit of its capacity must be avoided, as they would lead to a slowing down of the dosing itself and create the risk of operating errors.

Distributed IT systems are meant to allow the specialisation of a system to be combined with the operating ease of whoever is using it; they are not intended to result in the creation of IT cells. In the example illustrated here, an information network connects a series of basic stations that work by means of a single interface and that link up a dyeing room's vital control systems. The operator has at his disposal a record of dosing recipes, which details all the products and order in which they are transferred. Reproducing, with the help of the computer, the procedures normally used in dyeing, he can set the machines according to the required dosage quantities.

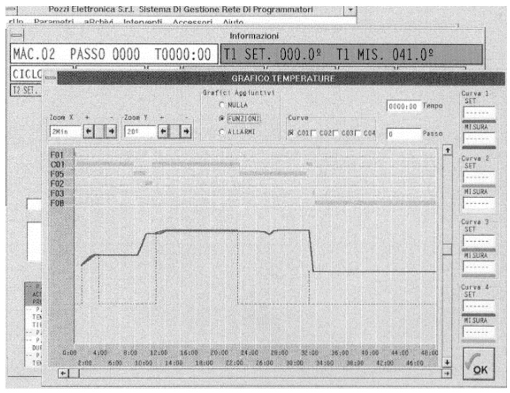
Given that a dyeing room may accommodate different types of machine, or machines that carry out various homogeneous processes, it is possible, in the installation stage, to group together the different machines, thereby simplifying their management and reducing the risk of errors.



A PC network system responsible for information storage and system surveillance



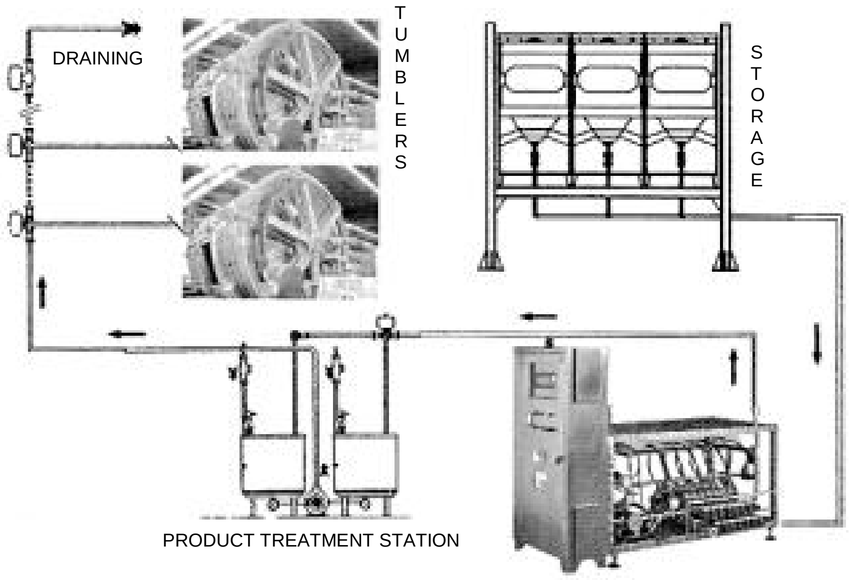
Recipes window



System temperature diagram window

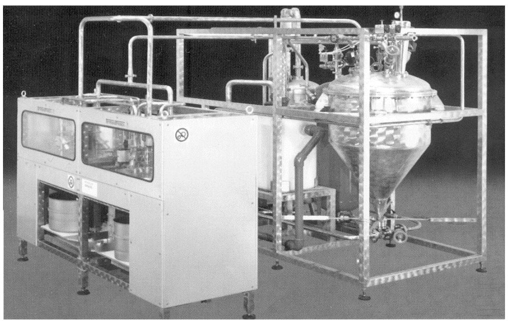
Applicative design and studies have led to the creation of compact and modular dosing systems equipped with hydraulic circuits that, using a single pump and distribution line, allow products to be drawn directly from the tanks, measured and conveyed to their point of use. The reading of the measuring, volumetric and solid-state instruments is carried out by a microprocessor connected up in feedback mode with a variable frequency drive that regulates the pump flow according to the programmed dosage quantities.

The level of precision obtained using this system is remarkable: > 50 cc. or > 50 g. with a dosing speed of 30/40 litres/min. The products dosed are conveyed directly to their distribution points, or to pre-treatment tanks for mixing with other products, or for heat treatments, and then via pumps fed into the production cycles.



Picture 191 - Compact modular dosing system

An important new development in the field of powdered dyestuff transportation and dissolving is the vacuum technique, which allows powder to be transferred directly from the weighing bucket to the mixer container, without the use of robots or manipulators. In this way, there is no escape of powder or vapours during the transfer stage as the system is completely devoid of hoods and exhausts, thus meeting all environmental and safety regulations. The speed of powder transfer ranges from 150 to 300 g/s depending on the chemical-physical nature of the product. Thanks to this high transfer speed, combined with the turbulence of the fume abatement water, the powder is subjected to a vigorous mixing action, which guarantees the elimination of germs and the perfect dilution of the dyestuff.
The mechanical action of the agitator combined with the emulsifying phenomena mentioned above result in perfect dilution of the powder in a far shorter time than is possible using traditional methods. Basically, the system is made up of two separate sections. One serves to empty the dyestuff buckets, and the other is made up of dilution containers. The systems are connected together only from an engineering point of view, therefore they do not have to be positioned in a particular way. The suction group can be single or double, as can the battery of dilution containers. The system can be used in-line with an automatic powder weighing system, or more simply, the powder bucket can be placed manually on the surface of the suction section. The pipes and transfer units are cleaned by suction and water.

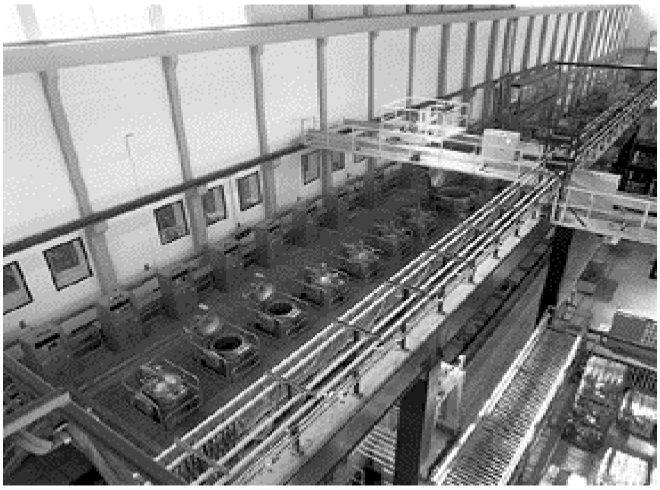


Picture 192 - Detail of a vacuum dosing system

The solution can be conveyed to the machines by means of a "single pipe" distribution system equipped with sorting valves that, in response to a specific command, divert the flow to the selected machine. The single pipe system offers a number of advantages in relation to systems that use separate pipes for each machine. These advantages include:
- the possibility of setting the quantity of rinsing water delivered to the machine according to the different capacities of the service tanks of the dyeing machine and the relative liquor ratios;
- the possibility of effecting rinsing cycles using limited quantities of water and of reaching speeds and pressure levels able to guarantee perfect cleaning of the line;
- rationalisation and simplification of the operations involved in transfer line installation.

AUTOMATED STORAGE

In completely automated systems, the storage, the unloading and loading of fabrics, the insertion and extraction of material carriers into/from yarn-dyeing autoclaves, transportation of materials, control of dyeing cycle parameters and the addition of dyestuffs and auxiliaries are all operations carried out by computer, in the absence of any human intervention.



Picture 193 - Completely robotised system for the dyeing of packages, equipped with hoists for the transportation of material carriers and for the loading/unloading of the machines

Warehouse automation is a relatively recent development and it constitutes a blend of various basic technologies: information technology, robotics, handling and transportation systems. Initially applied for the management of large quantities of small items (mechanical and electronic components, medicines, etc.), automated warehouses are now being used with an increasingly diverse range of products.
Because of the strategy of the warehouse, the company's whole production and organisational system has to be reviewed, and this brings to light three types of flow that, while different, are closely connected with one another, and all three have to be taken into consideration. They are: flow of materials, organisational flow, flow of information.
The warehouse is the heart of the system, around which all these flows revolve.
The type and size of the various inputs/outputs depends on the particular application, but incoming materials can nevertheless be split into two large families:
- materials originating from internal processes
- materials originating from external processes.

In many cases, where production is largely decentralised, the importance of the latter family will be considerably greater than that of the former.
The management system of an automated warehouse involves the digital processing of "opportune characteristics" and the exchanging of information with a host computer, which may be the company's existing host computer, or a different one, dedicated specifically to the warehouse.
The host computer sends the processor lists of withdrawals, destinations, and products being processed, and updates of records, while the processor sends the host computer the list of motions effected.
The management system (warehouse + transportation system) identifies and stores material that has been processed and withdraws materials to be sent for processing, in such a way that the situation in the warehouse can be monitored, second by second, through the creation of a physical map of items and processes.
As far as the textile sector (with all its general and specific problems) is concerned, it is easy to appreciate the growing importance of storage systems, particularly in view of the new organisational systems that tend to cut transit times of products, and whose aim is to guarantee quick service to an ever-changing market, while at the same time keeping no, or minimum warehouse stocks.

BENEFITS
Production cycle integration
Reduction of labour
Elimination of laborious tasks
Space savings
Repeatability of procedures
Reduction of errors
Greater productivity

LIMITS
Modification of the *modus operandi*
Plant and structure layout
Need for preliminary studies and customised solutions
Limited floorspace

HANDLING AND ROBOTISATION SYSTEMS

Automation and information technologies have led to the development of highly sophisticated solutions that allow the problem of handling to be approached no longer with simple mechanical solutions, but by conditioning the company's logistics through "intelligent" flow management that increases flexibility and adaptability.
The basic characteristics of automated transportation systems depend on the applications for which they are destined and on the environments in which they will be implemented, and they are strongly conditioned by the existing layout and structure of the buildings where the systems are housed.
In general, the following systems are found: tracks, ground, aerial tracks, and systems without physical support, or rather that acquire information through magnetic, optical or sonorous guides that do not necessitate any particular intervention on the existing structure of the buildings.
Transportation in textiles is a vast field, and this makes it difficult to provide meaningful examples. In short, it depends:
- on the type of product being transported (staple bales, bumps, comb sliver cans, spindles, packages, fabric rolls, folded pieces, print screens, dyestuff containers, etc.);
- on the type of machine that must connect with the transportation systems (operating machines, control, packaging, warehousing systems);
- the movement to be carried out (simple shifting, inclination of packages, grouping, etc.);

- on the degree of intelligence of the required operations, both on a sensory level (e.g., the capacity to modify behaviour according to the physical characteristics of the package or the environment) and on an operational level (as regards the IT management of articles received by the transportation system, the automatic definition of routes, destinations, etc.).

Practically any transportation problem in a textile company can be resolved through the application of currently existing technologies, adapted appropriately.

One problem that must be solved, if we are, in practice, to exploit automated handling systems in the textile field, is the standardisation of packages and formats.

This is relevant particularly to jobbers, who have no control over the specifications of the semi-processed goods they receive from their customers and on which they are required to work: size and shape of packages, tubes, methods of boxing up, type of pallet for packages and rolls, etc.

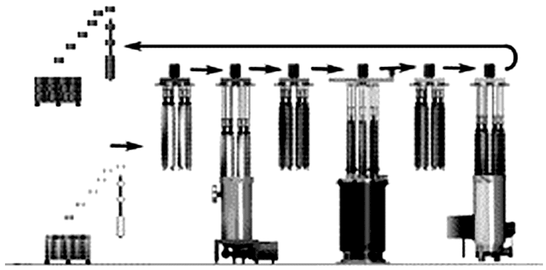
Another difficulty in the textile sector is the extreme variability of products and the small lots, which mean constant variations in flow and in the layout of the "virtual factory" that is periodically set up within the company. The trend today is to pursue greater and greater integration between transportation systems and the system (robotised or other) in operation at production level, in an effort to provide a flexible solution to a series of problems that emerge in the normal running of the plant. Indeed, a simple system for the physical transfer of semi-processed goods may well eliminate human labour, but it will not improve the company's production flexibility if, upstream and downstream, manual loading and unloading continues to be necessary.

BENEFITS
Greater efficiency thanks to an organisation of labour that is more rational and more coherent with production needs
Reduction of labour costs
Reduction of downtimes thanks to greater production cycle continuity
Reduction of errors
Reduction of laborious tasks
Space savings due to rationalisation of production cycles and layout
Reduction of intermediate storage

LIMITS
Modification of the *modus operandi* as a result of greater standardisation of packages and formats, plant layout and information flows
Rather high labour cost/investment cost ratio
Inflexibility of the system vis-à-vis the considerable variability of the textile production cycle (changing fashions, seasonal production, etc.)
Difficulty interfacing with existing machines

In reference to the application of robots in the textile industry, it is worth proposing a system based on the idea of creating an robotised dyeing, centrifuging and drying system, which would receive reels of yarn in special modular columns – the number of packages can vary according to requirements – and then deliver dyed and dried packages in the same columns.

Common to most traditional systems is the tendency to focus mainly on the dyeing stage itself. Indeed, for this particular stage, extremely sophisticated process automation solutions have been developed and the loading and unloading of the carriers has been specifically designed to optimise the operation of dyeing autoclaves.
However, this is often at the expense of the subsequent stages, i.e., centrifuging and drying, even though these, too, are part of the whole dyeing process.
As a result, complex systems have to be developed for transporting the packages from the dyeing carriers to the centrifuging hydroextractor and subsequently to the drying carriers, all of this generating considerable automation or, alternatively, labour costs.
With a view to making the whole transportation system more simple, reliable and economical, special dyeing and drying autoclaves have been developed that are designed to receive the yarn packages in special centrifugable columns. These are transported in modules that take six columns, and they are sent from the dyeing machine to the centrifuging hydroextractor and finally to the drying machine, thereby eliminating the need for specific package carriers.
The module comprising the six columns is, in fact, moved on a special automated overhead hoist equipped with multiple grippers; this makes it possible, in a single operation, to load the centrifuge to full capacity.



Picture 194 - Automated six-column module: photograph and diagram of package loading/unloading.

The size and volume of the dyeing autoclave has since been optimised in order to ensure the ideal liquor ratio.
In its most complete configuration, the system is as follows:
- Automatic store of packages for processing arranged on Europallets with cardboard or plastic dividers
- Automatic package depalletisation station, where the packages are loaded and possibly pressed on to vertical, centrifugable package carriers (columns). These columns are arranged on a platform following the ring configuration typical of the dyeing module (a circle of columns whose number is determined by the desired load). The loaded module is electronically weighed at this station.
- The circular modules are automatically lifted and moved (traditional package carriers no longer feature). The robot is an automated overhead hoist with automatic grippers that grasp the upper ends of the columns. The number and the ring arrangement of the grippers correspond to the number and ring arrangement of the columns making up the module; the two rings have the same diameter. They move in a synchronised manner on three spatial axes (X, Y, and Z) in order to move the columns, put them into and extract them from the different machines.
- Fully automatic dyeing units with vertical-axis and dyeing chamber and low liquor ratio. The units use the tried-and-tested air cushion dyeing technique and they are governed by the process computer based on a standard PC platform.Using volumetric reducers, the load can

be reduced to a minimum of two columns. The capacity of multiple systems can be reduced, maintaining a constant liquor ratio. This is done by isolating, using special valves, one or more modules; alternatively, modules can be parallel connected, in order to double the load. The system is based on a module of six columns, each column including 12 stacking 2-kg packages. As a result, each column weighs 24 kg and each module 144 kg.
- Hydroextractor that can accommodate the ring of centrifugable columns. The cycle is carried out entirely automatically by the process computer. The centrifugation cycle lasts an average of 15 minutes.
- Drying units with a vertical axis and circular chamber that carry out drying fully automatically with the end cycle governed by the weight of the material. There are normally 2 or 4 modules with a single filtering station, the latter driven by heated air. Since the circuit is open – the air, having passed through the yarn, is aspirated and conveyed to the exhaust stack – the modules can take yarns of different fibres, counts and colours without the risk of cross-contamination; perfect drying is guaranteed as the cycle end is determined by the weight of each individual module.
- Station where the dyed and dried packages are automatically unloaded from the modules' centrifugable columns. This is the same station that effected the loading operation, and it now places the packages on trucks to be sent for rewinding or, should the packages have to be transported elsewhere, for reloading of the Europallets.

Advantages of the system
- Centrifugable columns on which raw packages are loaded and from which, when finished, they are unloaded, without ever having been touched by human hand.
- Elimination of traditional package carriers
- The same ring configuration is valid for the dyeing unit, centrifuge and drying unit modules; this facilitates the automation considerably and thus increases the system's reliability and reduces costs
- Extreme loading flexibility
- Standardised hydroextractor
- Completely automated links with yarn warehouse.

MACHINE MONITORING SYSTEMS

The expression "machine monitoring systems" refers to those electronic-information systems that monitor:
- production output, in terms of quantities of semi-processed goods and/or physical events relating to semi-processed goods (number of picks on a loom, reasons for machine stops, number of packages unloaded from a winding machine, etc.);
- operating parameters relating to individual machines (mechanical settings, temperatures, pressure levels, etc.).

This family normally excludes those systems that control quality on line, and that therefore monitor technological and not purely production parameters. However, the boundary separating the two is very blurred.

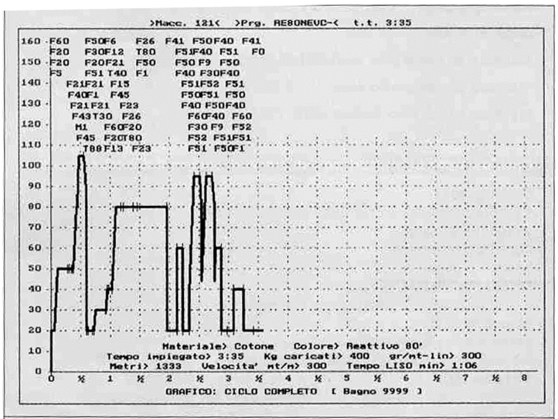
The task shared by all these systems is that of monitoring the physical values that can, to variable degrees, be correlated with the parameters that one wishes to monitor, and of allowing data processing in real-time or almost real time.

The actions that follow the data processing can range from a simple signalling to (at more sophisticated levels) self-adjustment of individual machines or of the entire department.
There are, essentially, two different categories of system:

1. **Monitoring of quantities produced and methods of operation.** This category embraces most systems used in companies for the direct monitoring of production methods; it is often not enough simply to monitor the number of single units produced; instead, this value needs to be correlated with the time it took to produce them, with the status of certain fundamental parameters, with events that occurred and with other collateral parameters. Systems belonging to this first category are now present in some considerable number on the textile market, and having got beyond the pioneering stages, they have now achieved high levels of reliability and technical features satisfying the market's requirements. Thus, they can be used for:
    1) real-time reading of machine status
    2) recording and cataloguing of machine events into log reports, also including untimely operator interventions
    3) the statistical processing of the above data
    4) the creation of dyeing cycles and the conveying of the same to the process controllers
    5) remote control of the machine
    6) planning the activities of the dyeing cell.

All monitoring systems also pilot the automatic dosing systems, acting as an interface with the dyeing machines' process controllers. They are easily added to existing mill equipment, without the need for complex mechanical or electronic adjustment operations. This clearly facilitates their installation. As regards their processing capacities, they are easy to personalise and often offer performances that are superfluous to effective information needs.

2. **Monitoring of department operating parameters.** The systems belonging to this category are ones that not only monitor, but also regulate machines that are dissimilar to one another but employed in a single setting. This function is usually achieved through the use of special processors and software procedures that can rarely be applied in exactly the same way in different production organisations. The monitoring of a dyeing room, or of a printing room, constitutes a good example, as here the production and management variables are complex as they are linked to machines that differ from one another. There thus arises the need for simultaneous management of different processes, involving different physical parameters. Systems belonging to this second category, when installed in finishing departments (dyeing, printing, wet and dry finishing), are rarely designed and created by the manufacturers of the individual operating units, precisely because they are designed to manage machines from different suppliers: this is thus the sphere of intervention of companies specialising in system integration.



Medesimo diagramma di tintura eseguito su Multiflow Ht dotata di vasca di preparazione (fondo scala fisso)

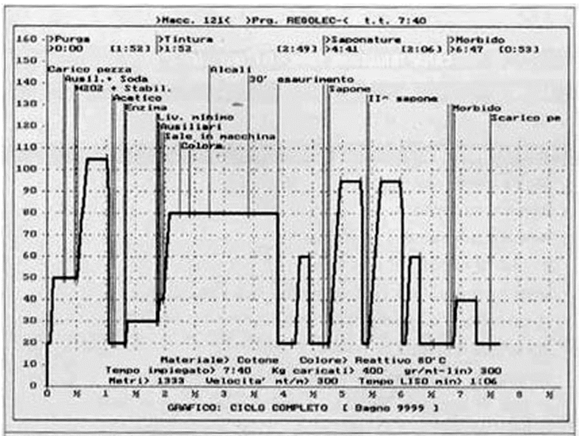


Diagramma di tintura di partenza su macchina Ht standard

BENEFITS
Improved quality and customer service
Reduction of machine stops thanks to better programming, organisation of labour and preventive maintenance
Increased productivity
Reduction of staff for checking tasks
Greater availability of real-time information that can be compared automatically and continuously
Improved planning in terms of quality, quantity and organisation
Possibility of carrying out preventive maintenance, thanks to the statistical analysis of data

LIMITS
Incompatibility with other information systems
Installation costs for replacement of microprocessors and for the development of software interface with existing controllers