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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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WET PROCESSING OF COTTON YARNS 1/

I.F. Mackin *

* J. & P. Coats, Ltd., Research Laboratory, Paisley, Renfrewshire, Scotland

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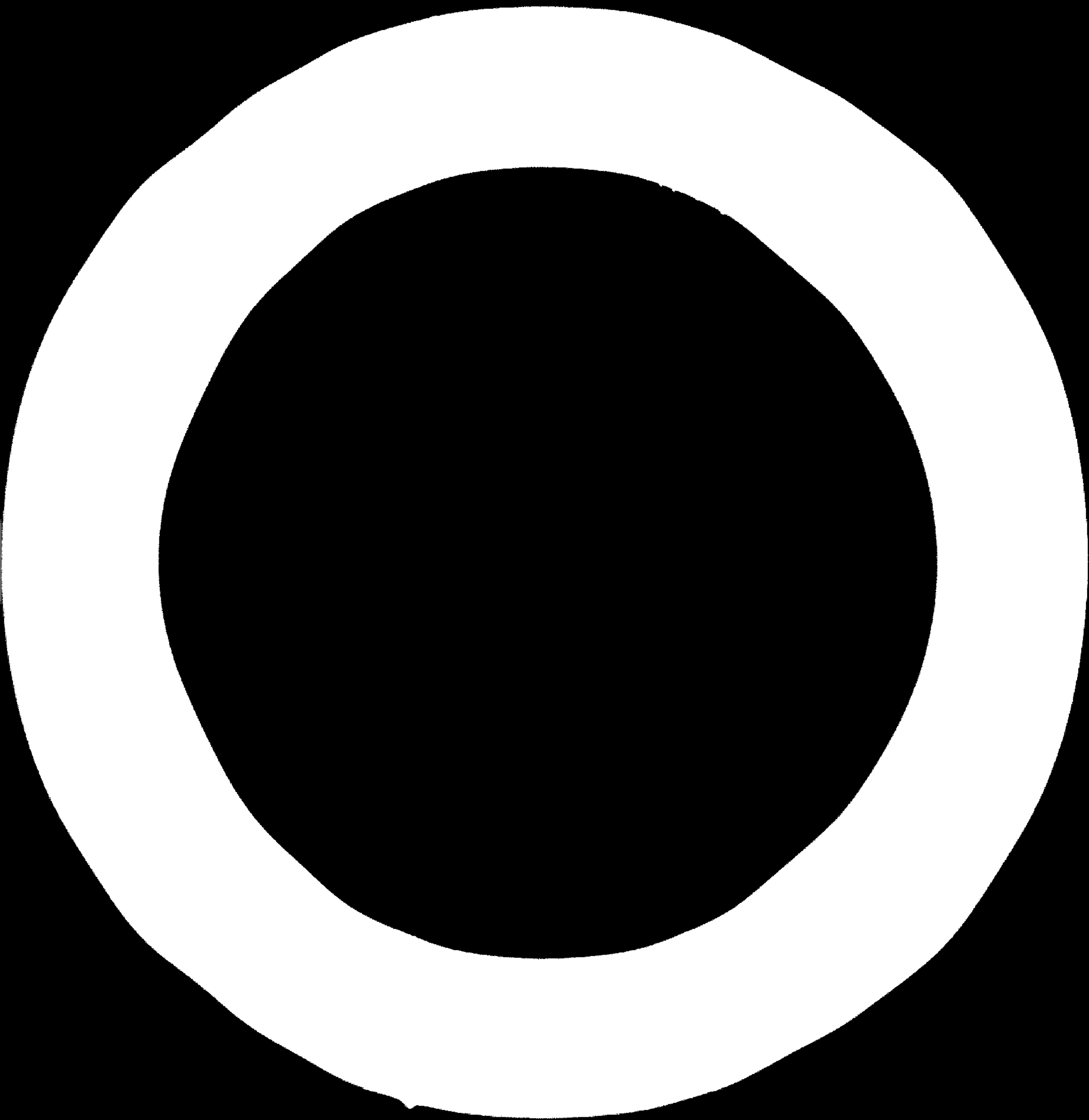

Wet Processing of Cotton Yarns

Introduction

Present day dyeing systems are the result of many years of development work, aimed at maintaining and improving quality standards against a background of high capital investment for equipment, increasing labour and material costs, and varying availability of fibres, dyes and drugs.

In these circumstances, the profitability of any dyeing organisation is increasingly difficult to maintain, so a constant awareness of changing attitudes, standards and techniques is essential for survival and progress.

In the following brief talk I shall outline the course of action which we have followed, in trying to lay down a rational basis for wet processing and control of cotton yarns, which permits assimilation of new techniques into daily production with minimal disturbance.

Water

The dyer has always considered his birthright to include an ample supply of good quality water, which he will use as he sees fit and then discharge it to waste by the easiest possible means at no cost to himself.

To the dyer the term 'good quality water' means a water free from impurities such as iron and copper salts, low in dissolved solids, and essentially soft in character. At the same time, the water should not contain too great a proportion of carbon dioxide otherwise corrosion problems are likely to occur. In present times, an abundant supply of such an ideal water is rarely available to the dyer from surface, river or well, due not only to natural circumstances, but also to contamination introduced to the water supply through the effluent discharge of other textile and manufacturing units.

Hence, it is almost invariable that some form of water treatment is necessary to reduce to acceptable levels, natural colour, bicarbonates, sulphates and chlorides of calcium magnesium and sodium as well as small quantities of other impurities such as silica, nitrate, fluoride and ferrous bicarbonate.

Treatments to nullify or minimise the effects of such impurities are by:

precipitation, or ion exchange with or without filtration.

The cost of raw water and the capital and operational costs of running a water treatment plant, occupy a significant place in the bleachers' and dyers' budget. Also, in present times there is the further heavy cost of effluent treatment required by law before an effluent will be acceptable for discharge to river or municipal sewer. These facts highlight the real advantages of water economy and control in existing processes, and should be carefully studied when new machinery and process routes are planned.

Water and effluent treatment plant often requires a large area if full treatment has to be accommodated. Also, as in all planning, clear specifications of quality and quantity must be established before the plant is designed.

General principles of water and effluent treatment are common knowledge, but in our experience the best plant and chemical treatment for any water or textile effluent, can only be established after skilled laboratory testing, evaluation, and collaboration with experts from local government water departments and with local agencies of international companies which specialise in plant design and installation. It is only with this local expert knowledge of the water, and its likely seasonal variations, that a generally satisfactory plant - but without guarantee - can be established.

On the effluent treatment side, the uncertainty introduced by variable production mixtures and new process developments cannot be fully catered for in advance, so space for development and expansion should always be kept available. The necessity of control of water and effluent plants cannot be overstressed, if optimum utilisation of the production unit is to be achieved. So often insufficient attention of management and responsible staff is paid to this essential process raw material. No longer can the job of indiscriminate and costly chemical dosage be left to the untrained, without the overriding supervision of instrumentation and technical control. Detailed recording and analysis of chemical and quality levels is an essential part of plant management.

Significant reductions in water (and heat) consumption are obtainable by following the principles of continuation baths in bleaching and of counter current washing e.g. in warp mercerising, and of recycling of batch circulating and running wash liquors e.g. in bleaching. Dissolved solids meters have been used with great success in these fields, as they not only provide a means of water control but also add control to the process itself.

As water charges increase year by year, we are clearly approaching the time when total water recycling will become economic. Many studies of decolourising exhaust dyebaths, together with regeneration of exhaust process water, have been reported in the literature.

Energy

Large quantities of thermal energy, and to a lesser degree electrical energy, are consumed by the textile wet processor. Different bleach/dye systems differ fundamentally in their energy requirements, although even within a particular bleaching or dye cycle the dyer may exercise control over individual parts of the cycle.

Against current high energy costs it is desirable that a full appreciation of the energy requirements of a dyehouse be built up in the form of an energy budget which is related to (a) the machine used for any operation and (b) the bleach/dye cycle applied in that machine to all relevant material loadings.

When this has been completed, individual steps within an overall cycle can then be examined with a view to reduction in energy requirement through elimination or shortening of that part of the cycle and/or of reclamation for re-use of heat energy or water. Furthermore, it is then possible to evaluate whether double drainage systems are economically viable to cover the installation costs of a heat recovery system from hot exhaust bath liquors and from heat scavenging of recirculated cooling liquors.

In batch processing, the fundamental relationship between liquor to goods ratio and energy usage, should always be borne in mind. The use of underloaded machines should be re[illegible] at all t[illegible] as this introduces marked losses in productivity due to in[illegible] use of energy and of labour as well as rendering bleach/dye formulation[illegible].

Modern developm[illegible] machinery have [illegible] the operating liquor ratio [illegible] machinery to [illegible] permits low thermal and electr[illegible] rapid dye systems. A word [illegible] here, however, as very l[illegible] liquor ratio applications can introduce problems of unlevelness in batch [illegible] and [illegible] present dye solubilisation problems for heavy sh[illegible] dyeing.

The economics of drying and [illegible]traction power to drying should also be kept under constant review. Analy[illegible] of records of cost and efficiency of these ancillary processes [illegible] light if and when corrective action is required. Very considerable heat losses can occur due to such machines standing in a hot condition between runs so production planning must always be closely linked to dyeworks production flow

Mercerising

The mercerising process introduces changes to cotton yarns e.g. increase in lustre, increase in tensile strength and increase in dye affinity.

If tension is applied, mercerisation generally causes an increase in strength from 10% to 40% depending on the yarn construction.

The moisture content based on the dry weight of the cotton increases with the concentration of caustic soda used. The percentage moisture present ranges from 6-12%.

Affinity for Dyestuffs

The weight of dyestuff absorbed increases with increasing concentration of caustic soda up to 13.5% (30° Tw) (19° Be) and thereafter the increase is less rapid. Tension applied and drying also have an effect on the affinity. The effect of tension is to decrease the amount of dye absorbed when compared with a yarn mercerised without tension. Drying a mercerised yarn decreases the affinity for dyestuff, this decrease being greater the higher the temperature of drying.

Due to this change in affinity for dyestuffs, air drying of mercerised cotton must be avoided after the yarn has been mercerised and before it is passed on to the next process. Precautions must be taken to keep such yarn wet, otherwise unlevelness in dyeing is likely to occur.

Wetting Agents in Mercerising

Wetting agents are added to mercerising liquors in order to obtain quick penetration of the caustic soda solution. Several types of such agents are available. The most commonly used is Cresol which is relatively cheap in price. A small amount of a higher alcohol such as Butyl Carbitol or Butyl Cellosolve is added to assist penetration and as an anti-foam.

To get the best use of a wetting agent it should be soluble and have good stability in caustic soda solution of mercerising strength (53-54° Tw) (30-31° Be). In some cases an added advantage is found if the wetting agent is soluble in strong caustic solution (76-80° Tw) (40-41° Be) used as feed liquor to the mercerising machine. By this means, the necessity for adding wetting agent to each of the machine tanks can be avoided, if facilities exist for providing a strong liquor feed line to each machine.

The quantity of agent used is about 1-2% by volume. This quantity should be sufficient to giving a wetting time of 4-5 seconds under the standardised testing conditions for wetting out.

Tests to check the wetting out properties of the mercerising liquors should be made every four hours or as necessity demands.

In some cases the use of cresylic wetting agents is prohibited by local authorities due to contamination of drainage areas with phenolic compounds which exist in the wetting agent. Recourse must then be made to alternative supplies of wetting agents produced from non-phenolic compounds, e.g. Leophen, Floranit etc.

An advantage in the use of wetting agents of the cresylic type is that they can usually be recovered where facilities exist for caustic recovery.

Mercerising Machines

In hank mercerising two types of machine are used, namely:

a) Vertical type (Haubold)

b) Horizontal type (Bonnet, Jaeggli and Kleinewefers).

These machines are automatic in action and carry out the mercerising process according to the conditions previously set down. The control mechanism consists of a series of tappet wheels which set the various operations in movement. In the Bonnet and J[illegible] machines control is exercised by a series of cams of special design.

The mercerising cycle may be divided up into the undernoted operations:

1) Wetting out of hank.

2) Impregnation in caustic soda of mercerising strength (53-54° Tw) (30° Be).

3) Squeezing with drainage of caustic solution back to storage tank.

4) Hot wash.

5) Cold wash.

During the mercerising cycle the thread is subject to shrinking and stretching effect. This has an effect on the character of the lustre obtained, and also on the appearance of the finished article. The exact point of shrinkage depends on the type of machine used, but one important condition applicable to all is that the maximum tension on the thread should take place not later than 10-15 seconds from the commencement of the hot wash. If there is too long an interval between the commencement of the hot wash and the attainment of maximum tension, some damage from broken ends may occur. This is due to the fact that the thread has lost some of its plasticity resulting in breakage. Other factors of influence are the twist and coarseness of the threads concerned.

It should be pointed out that one advantage of the horizontal machine as compared to the vertical machine is that in the former one half of the hank is immersed in the caustic solution, while in the latter only about one third of the hank is in contact with the caustic soda solution. The horizontal machine, therefore, tends to give better and quicker wetting-out of hanks.

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Caustic Soda Recovery

The economics of caustic recovery depend on many factors which include :

a) the availability and cost of fresh caustic soda

b) the possible reuse of caustic soda wash liquors in other processes, e.g. vat dyeing or caustic kier boiling without concentrating,

c) the cost of neutralisation for efficient effluent treatment,

d) the availability of a sufficient supply of caustic wash liquors to permit caustic recovery plant operation on a continuous basis,

e) steam availability from existing boiler plant.

Modern caustic concentrators are small and apart from providing recovered mercerising strength caustic, also provide a copious hot water supply for general processing.

Liquid Ammonia Treatment

Liquid ammonia can be regarded simply as a new medium for tailoring the dimensions and properties of cellulosic materials. It confers opportunities for the cellulosic materials to shrink, swell, stretch and relax and can therefore be used to obtain a variety of effects on many materials.

The economics of cotton yarn manufacture hinge on the price of raw material comprising it, e.g. more than 25% of the cost of a cotton sewing thread is accounted for by the raw cotton price. An accepted yardstick of a cotton is the strength it produces in yarn and thread forms and it was to this end that much of the development work of the liquid ammonia treatment process was designed.

Properties of Liquid Ammonia Treated Yarns

The following properties have been established for liquid ammonia treated yarns.

1) Tensile strength significantly increases.

2) The elongation at break is only about ⅔rds that of untreated yarn.

3) Loop strength and knot strength increase slightly.

4) Abrasion resistance is reduced but this decrease is less than for caustic soda mercerising.

5) After bleaching or dyeing, treated yarns have virtually zero shrinkage when treated in boiling water.

6) A pleasing lustre is imparted to the treated yarn albeit slightly less than for caustic mercerising.

7) Dye affinity is increased by about ½ of the amount attained by caustic mercerising.

8) Moisture absorption is increased but again to a somewhat lesser degree than for caustic mercerising.

9) The heat resistance is substantially increased.

Liquid ammonia treated yarns are significantly cheaper per Kg. than mercerised due entirely to the elimination of expensive hank winding or warp splitting processes.

The elimination of hank winding is possible, due to the high speed reaction in liquid ammonia which permits package to package processing.

Maximum strength increases, require maximum stretch in the ammonia moving zone but this is difficult to apply without breakage to yarns. However, if the stretch is reduced and more modest strength increases accepted (of the order of 20% - 30%) it is readily possible to liquid ammonia treat singles yarn. This is a sharp contrast to the difficulties in processing singles yarn by mercerising.

It is therefore possible to produce by this means a lustrous singles yarn for use in weaving and knitting applications.

From the ecological view point also, ammonia is more readily and cheaply recoverable than caustic mercerising liquors which produce effluent and which has to be disposed of. The problem of caustic liquor discharge to rivers is so ecute in some countries that permission to erect mercerising plants is difficult to obtain.

Early difficulties of dye affinity variations between packages of liquor ammonia treated yarns have now been eliminated by improved control of the treatment process.

The technological difficulties of converting pressurised liquid ammonia and recovering pressurised liquid ammonia from the gas evolved during the process, have been successfully overcome.

Bleaching

Traditional bleaching of cotton by means of hypochlorite is now challenged by other agencies, particularly -

Hydrogen Peroxide and Sodium Chlorite

The possible advantages of peroxide as a bleaching agent compared to hypochlorite are -

1) Shorter processing times by a reduction in the number of stages of processing.
2) Less danger of general chemical damage a result of greater margin of safety in control.
3) Peroxide liquors are less corrosive than hypochlorite towards stainless steel. This is of particular advantage when considering package bleaching.

Depending on the end use of the bleached yarn, all of these advantages may be nullified by the occurrence of pin-point or local chemical damage as a result of catalysed decomposition of peroxide due to trace metals.

Very extensive Research work has been carried out by the manufacturers of Peroxide with special emphasis on bath stability and removal of the offending trace metals by means of acid souring and sequestering agents, and while great progress has been made, the problem has not been fully resolved.

Peroxide forms the bleaching basis of the single bath bleach/dye processes introduced by several dye manufacturers.

Sodium Chlorite

The use of sodium chlorite as a bleaching agent has been the subject of extensive study and report.

Various methods of bleaching with sodium chlorite alone and in conjunction with other agents, e.g. hydrogen peroxide or hypochlorite, have been suggested and are, in some cases, in use in the textile industry. It is however, more generally used in acid solution.

The principal advantages of sodium chlorite as a bleaching agent are:

1) Shorter processing times than for hypochlorite by a reduction in the number of stages of processing.
2) In bleaching of cotton much less risk of tendering than with hypochlorite or peroxide.
3) The stability of the commercial powder when stored properly.

Against these advantages several notable disadvantages of sodium chlorite as a cotton bleaching agent are:

a) the corrosive action of hot acidified solutions of sodium chlorite on all common metals and alloys including normal textile machine grades of stainless steels,
b) the relatively high cost of chemicals compared to those used in hypochlorite bleaching process.
c) the toxic nature of chlorine dioxide gas which is evolved from hot acidified bleaching solutions.

Dyeing

Following on this theme of control, we have established to our own total satisfaction that the greatest productivity rewards are obtainable by successfully dyeing to shade, levelness and penetration 'first time' without interrupting the dye cycle to check shade and make a dye addition correction. The effect of sampling during a batch cotton dyeing, of say a reactive or vat, increases the theoretical process cycle time by about 25%. Furthermore when the 'bit' or sample used for colour control at this stage is compared critically against the bulk end result and the master colour standard, significant differences are found in a high percentage of shades. These differences are due presumably to differences in times/temperatures and concentrations of oxidisation, soaping, drying and conditioning between sample and bulk. Hence, the relative worth of the sample has been shown to be low. It should be further noted that apart from the lose in machine productivity, high labour costs of the machine operative and colour matching supervisor have been incurred.

Further investigation into the incidence of dyeing unlevelness of batch dyeing, have shown conclusively that redipping, i.e. the addition of colour during a dyeing proceee, is the main cause of dyeing unlevelness in bulk dyeing.

This procedure of dyeing to the standard formula without recourse to shade checking during the cycle has been designated 'Blind Dyeing'.

It is appropriate now to consider the factore which have been found to have a significant effect on the dyeing of cotton fibres and to consider how these should be controlled so that dyeinge are within a prescribed colour tolerance when dyed from standard formula, i.e. without additions or retreatments.

The following factore have been found to have a significant effect on the resultant shade after dyeing :

the cotton fibre, its colour, the construction of the yarn, pre and post dyeing wet process treatmente and most important of all, the application of dyestuff.

In general, the basic factore of cotton quality and yarn construction are outwith the wet processers control and it is not my intentions to comment further on these.

Pre-dyeing treatments such as scouring/bleaching, reduce the variable conditions of the cotton colour base due to the removal of non-cellulosic material and colour of cotton and hence are an aid to provide a more uniform base for dyeing.

In the application of dyestuff to the fibre, the resultant shade is influenced by -

a) the weight of the yarn

b) the weight of the dyestuff

c) the volume of the dye liquor

d) the amount of electrolyte

e) the temperature of dyeing

f) the time of dyeing

It is these factors which the dyer must control to ensure satisfactory level, well penetrated, on shade dyeings from standard formula.

It has been possible through statistical analyses of laboratory and bulk dyeing results to establish degrees of permissable variance from ideal in these factors while still maintaining an overall satisfactory result. In total, the sum of the individual variations in these factors must not exceed an overall result, otherwise the goal of Blind Dyeing from standard formula will not be achieved.

It is obvious, however, that the Blind Dyeing technique is only applicable to dyeing recipes which stand a high percentage chance of success. The general approach to this problem which we follow and recommend would be:-

a) a critical selection of individual dyes and comptabile combinations of these dyes based on target fastness considerations.

b) study the economics of these prospective dye combinations and build a system in which the technical performance of the combinations would be prime importance followed immediately by cost and fastness.

It is clear that by building such a system that the overall advantages to be varied from Standard Formula dyeing may involve dyes which are not necessarily the cheapest on a £/Kg basis but which in fact stand a much better chance of successful application without redipping or further retreatment.

The moulding of these dyes and combinations into a system of recipe prediction and control will depend on the availability of services, staff and equipment. It may be that laboratory matching of individual shades will be followed, otherwise advanced and sophisticated systems of spectrophotometer and colour control may be available.

The problems of metamerism could be covered by either of these systems.

Having now prepared the recipe its successful transfer to the production dyehouse will fall on production staff rather than on the recipe maker and it is the responsibility of the bulk dyer to apply the recipe and procedure with the same analytical accuracy with which it was prepared. It is quite pointless to attempt to Standard Formula Blind dye in bulk, if the bulk dyer cannot achieve a high degree of reproducibility from his machinery and procedures.

At this stage in the production chain we have arrived at a part which we consider to be of most critical importance, i.e. the dispensing and dissolving of the dyestuffs for the bulk dyeing.

We have found over many years that more trouble is introduced during dye weighing and preparation than at any other stage in the wet process route. It has been established also that the incidence of error in calculation and transcription of information from one paper to another (e.g. in scaling up of recipe to bulk) is high and it is clearly at this stage that check controls are absolutely necessary if successful Blind Dyeing is to be achieved.

To compliment this accuracy in colour weighing and dissolving, it is vital to measure and control the colour strength of dyestuffs as received from the dye manufacturers and to store these standardised dyes under prescribed conditions of temperature and humidity closely allied to those used by the dye manufacturer when he dries and packs the dye at the manufacturing stage.

Many dyestuffs are highly hygroscopic so it is necessary to control the environment of open dye stock within close limits to obviate the effects of atmospheric conditions. If this is not done, the strength of the dyestuff will change due to absorption of moisture and the prospect of ever achieving a high degree of colour match from standard formula will be very poor indeed. It is our view that all dye stores should be air conditioned and that they be isolated from all wet areas by double doors. Dispensing hatches should likewise be built on this double door principle.

The preparation of the dyestuff solution by careful wetting and thorough dissolving is of critical importance. It is pointless to instal expensive and accurate weighing machinery controlled possibly by a computer or print out system to have all of this spoiled by unsatisfactory dissolving and transfer of dye solution to the dyeing machine.

It is commonly found that operatives involved in the preparation of dyes and drugs have no appreciation of the degree to which they can potentially destroy the colour value of a dyestuff and that their essential function is to mix, dissolve and transport the dissolved dye to the machine without spillage or spoilage.

Modern equipment is available to aid dissolving and transfer of prepared dyes and drugs to the dyeing machine, but here again this is useless if this equipment is not kept in conditions of clinical cleanliness.

Machine Control

The control of machine functions which was once the prerogative of the dyeing operative, has been largely taken over by instrumentation in varying degrees of sophistication.

On new equipment, the locking of the lid, the filling and draining of the machine, the time/temperature and flow directional sequences, are now achieved by pressing the appropriate button or letting the process be masterminded by the computer or other Full Automatic Controller.

Claims of outstanding savings in dyes, drugs, water and steam and remarkable increases in productivity are commonly reported from F.A.C. dyeing machinery.

Such claims can be most misleading, as it is quite clear that most of the savings claimed could have been achieved by applying accurate control of the weighing and dispensing processes for dyes, auxiliaries and chemicals, by controlling the preparation and weight of the textile presented for dyeing, and by controlling the process within the dyeing unit.

The savings directly attributable to fully automatic control are not large, as the variables controlled by the F.A.C. controller are of second order of importance only. It follows therefore that sophisticated control equipment is not a fundamental pre-requisite for efficient dyehouse operation. If sound basic training [illegible] given to machine and [illegible] operatives, and this is backed by the services [illegible] of dyes, etc. there is no reason why a very high degree of efficiency and proficiency should not be achieved from the non-F.A.C. dyehouse.

Machinery

In recent years all major machinery manufacturers have shown an increasing interest in developing machinery which could be designated "Rapid Dyeing". These have been designed to speed up the major dye cycle steps of -

a) Heating
b) Cooling
c) Time at top temperature
d) Number and duration of washing treatments
e) Filling and draining times

by means of -

i) Increasing the rates of heating and cooling
ii) eliminating cooling by discharging high temperature dye liquors directly to specially designed drains

iii) the use of vacuum techniques to speed the rate of filling of kiers and of vacuum extraction between baths as an aid to cleansing and drying.

iv) the use of separate stock and preparation tanks

v) increasing liquor flow rates

vi) increasing the frequency of change of direction of liquor flow.

Some of these developments have been successful while some have had unfortunate effects. It is most important that a careful and critical specification of requirements be made before purchasing machinery possessing some or all of these special and expensive attributes.

Very rapid rates of heating can effect reduction in cycle times but also can create huge peak demands on steam supply which cannot always be met if a large number of machines are involved.

High liquor flow rates have been claimed to reduce the time required at top temperature but the effects are small for the large flow rates applied. Also in cheese package dyeing where one cheese is in contact with other cheeses on the column, fibre damage due to rubbing can result from excessively high flow rates.

Drying

The partial and total removal of moisture from cotton is expensive in energy and may be prolonged in time. The following comment covers drying of yarn in hank and package form.

As a preliminary it is worthwhile to consider the process of hydroextraction which, in the more efficient mechanical systems, reduces the water content in the yarn to approximately 50% of the dry weight. Vacuum suction and pressure blowing systems are significantly less efficient in water removal.

Hydroextraction is normally applied to all cotton yarn in hank form but can sometimes be omitted with packages subsequently to be rapid dried, when the cheeses are entered into the drier 'wet'.

Two types of Hydroextractors may be mentioned:

i) Basket-type extractor

ii) Single-spindle type extractor

of which (i) is used for both hank and package forms while (ii) is limited to thread in package form.

The time of extraction with the basket type extractor, is variable though up to 20 mins. is advisable for white packages to reduce staining due to the migration of impurities. The degree of extraction varies with the type of yarn and time of extraction. On account of the difference in viscosities between hot and cold water, a higher degree of extraction is achieved with yarn finished from a hot water bath than yarn finished cold.

The single spindle type of extractor for packages is of more recent design and has the following advantages over the basket type extractor -

a) practically no package distortion

b) a mixture of shades can be extracted while the machine is running continuously.

To set against these, however, is the fact that different extractor heads would be required for packages of different size, e.g. 5½" and 6½".

e) Drying of cotton yarn in hank form

All hank yarn is previously basket extracted and is normally dried by blowing hot air over it as it passes, hanging on poles, through some stove.

A modern variation of the pole drier employs radio frequency energy where the extracted yarn is placed on a conveyor belt which passes between the plate of the radio frequency drier.

Radio Frequency drying is expensive in electrical power and is a greater fire risk than conventional hot air driers due to occasional electrical discharge between the plates.

Radio Frequency drying is fairly quick and has the added advantage of drying to a predetermined moisture content.

b) **Package Drying**

With the increasing importance of package processing, it became desirable to find some quicker method of drying cotton yarns, as conventional hot chamber drying required drying times of the order of two days for large diameter cotton packages.

Forced air circulation rapid driers operating at atmospheric and high pressure, have been developed along with single and multi chamber stoves with forced air circulation through the packages.

The advantages of rapid driers are:

i) Much reduced time required.

ii) In many cases no unloading from the carrier after dyeing is necessary.

iii) Higher temperatures could be achieved and dangers of migration of colours and 'bronzing' of blacks reduced.

iv) Low labour costs

To be set against these, however, were the following inherent disadvantages:

i) Very high power consumpt with a large initial surge. This is particularly relevant where electrical power is at a premium.

ii) High noise factor attendant in these machines although modern multistage driers are better in this respect.

iii) Time to effect repairs on rapid drier is often prolonged.

Most major machine manufacturers have shown interest in the development of driers and many versions and sizes are available.

Also, as was noted previously, the radio frequency technique has application to package drying with the proviso that steel spring or solid centres should not be used as these tend to increase arcing prospects.

In the assessment of rapid drying systems, we would recommend the following:

a) only stainless steel equipment should be used for pressurised rapid drying,

b) the choice of high medium or atmospheric types of rapid driers should be made by comparing their capital and running costs for the particular package system,

c) a minimum of two machines plus spares is required for any system to provide protection from mechanical failures at all times,

d) an installation comprising a larger number of small machines rather than the minimum number of large machines is advisable on account of -

   i) the organisation of drying would be improved by avoiding in many cases the necessity to mix (i.e. unload and reload) different shades in the same machine,

   ii) the effect of one machine being out of action would not be so drastic.

A new two phase drying system is now available [illegible]) which is claimed to improve the uniformity of residual humidity, improve yarn quality, lower power consumpt with a short drying cycle.

The system is based preferably on two kiers which are alternately heated to a certain temperature with hot air and then evacuated, thus using the heat energy to vaporise the humidity.

Drying temperatures of the order of 75°C. are claimed against conventional rapid drier temperatures of 120°C.

Efficiency comparisons by the manufacturers indicate a steam saving of more than 50% over conventional high pressure and atmospheric driers.

Dyestuff Supply

In recent years a number of dyes have been withdrawn due to health hazard in manufacture, rationalisation of the ranges or manufacturing difficulty caused by variable intermediate supply.

The manufacture of dyes based on Benzidene has now almost ceased in West Europe due to the carcinogenic nature of this intermediate. Although, supplies of Benzidene based dyes are still available from East Europe and certain Asiatic countries. Cheap replacement dyes based on alternatives to Benzidene have not been forthcoming. This has resulted in a large number of azo dyes disappearing from the market with Direct dyes being mainly affected.

Alcian dyes are now no longer being made, also certain Naphthols, both due to health hazard at manufacture.

Copper Aftertreated Directs and Sulphur dyes are likely to find restricted use and many are likely to be withdrawn as effluent specifications for trace metals and sulphides become more stringent. Alternative reduction systems for Sulphur dyes, e.g. Glucose, are suitable for certain Sulphur dyestuffs.

It appears that Indigoid Vat dyes are being phased out by the manufacturers probably due to processing difficulties and costs, and the partial overlap of Reactives in this part of the colour gamut.

Different manufacturers hold widely different views on the future of Vats as a class. Indications from some manufacturers are that the production costs of Vats will virtually force dyers off Vats and on to Reactives.

At the present time reactive dyes are taking an ever increasing share of the market for wash fast dyed cotton yarns. In comparison with Vat dyes they have good wet fastness, a much wider colour gamut, are easier to apply and possess, better level dyeing properties and are now fairly cheap. There are indications that some dye manufacturers are contemplating withdrawing from production of Vat dyes and concentrating their efforts on various types of Reactives.

For the yarn dyer, however, a total 'Reactive' dyehouse would involve the handling and discharge of vast quantities of salt and alkali. Also, the solubility of many Reactive dyes in presence of high electrolyte concentrations at low liquor ratios is inadequate for heavy depth shades.

Ref: Wet Processing of Cotton Yarns

When attempting to dye deep shades, e.g. navy blues and dark browns, fibre saturation is approached with a corresponding reduction in degree of fixation. The net result is that large quantities of dyestuff (10-15%) are necessary to achieve this type of shade.

The cross-linking of cellulose chains by dyes containing dichloro triazine or quinoxaline reactive groups is well known. It has been noted recently, however, that yarn strength reductions of the order of 4-8% can occur when due to reaction.

Being mainly azo compounds, Reactive dyes lack the fastness to hypochlorite bleaching which Vat dyes possess. This particular property is of importance depending on the location where the dyed goods are sold, e.g. the housewife in U.K. and North Europe does not tend to bleach coloured goods when washing, whereas in U.S.A., South America, Southern Europe etc. bleach is often incorporated in the wash. For truly fast dyed articles Vat dyes are still the main class.

It has been noted that in package dyeing it is difficult to remove all the alkali in the washes following the dyeing phase. This can result in soda-marking of the packages after drying and sometimes precipitation of calcium and magnesium salts from the water. A recent development by I.C.I. (Germany and Holland) postulates the replacement of the large quantities of soda ash with a much smaller quantity of soda and caustic soda to give the optimum reaction pH.

The most significant development in Reactive dyeing is the high fixation dye of which Procion H-E is a prime example. These dyes contain two reactive groups and have a higher affinity for cellulose and are relatively insensitive to liquor ratio changes.

It is interesting to note that while the heat energy required to apply Reactive dyes may be low, considerable quantities of water and energy are required to 'finish off' Reactive dyed goods, especially in heavy depth shades.

Azoic Dyeing

Naphthol dyestuff have traditionally been applied by the multi-stage route of impregnation, hydroextraction/rinsing and development.

German and Swiss manufacturers have now developed a one-bath application process which offers a real rationalisation of the dyeing process. This one-bath process is cotton in hank in open becks and spray dyeing units and cotton piece on the winch.

The basis of the method is to retain the bath after impregnation and maintain the colour pigment which is formed during development in a highly despersed form, by means of a special auxiliary. The one-bath method consists of -

a) Impregnation for about 30 mins. at 20-30°C.

b) Addition of acid and diazo solution without letting off the bath.

c) Coupling the dyestuff of about 30 mins.

d) Cleansing aftertreatment.

A fairly wide selection of naphthol/base combinations are suitable for this process.

One bath dyeing of cellulosic blends

A number of one bath methods have been developed for cellulosic blend dyeing. Disperse/Direct dyeing of Cotton/Nylon or polyester is well known although of little practised use because of the poor wet fastness, except in pale shades.

Disperse/Reactive: Methods based on hot dyeing Reactive dyes in which the Disperse and Reactive dyes are added to the bath with 5 g.p.l. of Resest Salt L (m-nitro sodium benzene sulphuric acid) which prevents hydrolysis of the Reactive group. Dyeing of the polyester is first carried out at 120°C. then the bath is cooled to 80°C. Electrolyte is added and dyeing of the cotton proceeds in the usual way.

Disperse/Vat: Disperse and Vat (pigment) dyes are added to the bath plus a large quantity of dispersing agent. Dyeing at 100° - 130°C. proceeds then the bath is cooled to 80°C. and caustic soda and hydrosulphite are added and dyeing of the cotton carried out. There are several Union dyes (Cottestren) on the market using this principle. These commercial blends have to be formulated for a predetermined fibre mix and may turn out to be uneconomic for a customer's particular end use and furthermore may not give solid shade dyeing under adverse conditions of application.

Nylon/Cotton: A Hoechst patent for single bath application Reactive/Metal complex dyes has the following method. Add dyestuff and alkali to give pH 8-12 and raise temperature to 80°C. to dye the cotton. The pH is then reduced to 6.5 - 7 by the addition of acid. The temperature is raised to 95°C. and the nylon portion is dyed. Acid dyes will precipitate under these conditions, metal complex dyes will not.

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There is currently a wide interest in multicolour effect dyeing for cotton yarns which is covered briefly by the following:

1. Knit de Knit

Fleissner T.A.G. System - There is not a great deal known about this system other than good control of dye liquor application is achieved. A Ciba-Geigy patent (BP 1,154,597) describes the printing of fabric with stripes prior to being unravelled.

2. Warp Printing

The Stalwart/Pickering process has yarn passing above rollers which are rotating in dye liquor. At intervals, rollers are depressed holding the yarn for certain lengths of time in contact with the liquor.

In the Pickering-Embec-Laing Controlled Area Yarn Dyeing Machine, a web of 432 ends passes between four sets of embossed rubber application rollers.

A process by Henry Ashwell & Co. has a special coiling device which lays the yarn on an endless belt. The coils pass between four pairs of rollers, the bottom of each set having a foam strip which applies the colour. The yarn is then dried, hanked and steamed in an autoclave.

Courtaulds (BP 921,166) have a system whereby dye is applied at spaced intervals by intermittently moving a yarn transversely into a nip formed between two rollers carrying the dye.

A Toyo Rayon KK patent (BP 991,327) has an electromagnetic vibrator bringing yarn into contact with a dye applicator.

Singer-Cobble Ltd. (BP 1,152,043) system has dye applied intermittently to yarns running in a grooved roller surface. Variation in applied pressure influences the shade obtained.

Chitte, Koecke & Co. (BP 1,164,852) have an integrated system allowing steaming, shrinking, dyeing etc. Space dyeing is achieved by controlling the dye supply with a Jacquard device directly associated with the fluid treatment chamber.

Toyo Rayon KK (BP 1,137,415) have another patent whereby a tensioned yarn is intermittently reciprocated to bring it into contact with a jet of dye liquor.

The Zaza machine consists of four printing heads, each consisting of a felt covered roller running in a trough of dye liquor. The yarn runs above the felt roller but is brought into contact by bars above the yarn path. A pattern of spots in four colours is produced. In the O.P.I. (French Patent 7,002,183) system, the yarn passes under reciprocating jets of liquor, which give the random effect, then into an extractor. The extractor consists of a tube with special contours to give a venturi type effect. By varying the air pressure, the residual moisture contact is controlled and it is also claimed that the definition of colour spots can be more precisely controlled.

The machine is built to process 8 ends of yarn with three circulation systems for dye liquor. Running speeds, on acrylic yarn, of 500 m/min. are claimed.

3. Hank Dyeing

There is little required in the way of equipment for Dip, Clip or Tie dyeing of hanks.

A patent of the Duplan Corporation involves affixing constricting bands to the middle portion of hanks so that on steaming a differential affinity is imparted to the exposed ends.

Spraying of hanks, either singly or in multiples, is now the standard means of producing random effects.

In the Multispace Dyer of Callebaut de Blicquy, the hank is sprayed by nozzles imparting up to 4 colours with bands of 25-1075 mm. Fixation is by steaming while the hank is on a conveyor belt with a maximum time of 16 mins. Productivity of 250 lbs./hour is claimed. In December, 1974 the cost was £30,000.

The Hussong-Walker-Davis machine sprays different section of the hank to produce either variegated or a variety of colour ombré effects. Solid shades are produced by rotating the arm on which the hanks rest until all of the hank has been sprayed. Very short dye application cycles are possible from this unit.

4. Package Impregnation

In the Astro Dyein Process (BP 1,035,443) yarn is dyed without any pattern by injecting the package with dyestuff through hypodermic needles.

In the Sectocolour Process, yarns on cone are sealed off in compartments and each fed with different coloured liquors. The dye is fed through the cone both by pressure and hydraulic action.

A B.A.S.F. development (Belgian Patent 657,783) is a variation of package injection. Special needles with several orifices introduce the liquor into a package specially wound to avoid differences in levelness.

5. Spray or Jet Printing

The best known of these processes in the I.C.I. Polychromatic Dyeing Process which was developed specifically for fabric but which is applicable to yarn. Thickened dye liquor is applied in a random fashion by reciprocating jets in either of two ways:

a) Directly on the fabric which is then passed through a mangle, or
b) On the top bowl of a mangle which then impregnates and nips at the same time.

The Tech-Dye Process of Walter Carpet Mills applies 2-5 colours in a continuous spot-dye operation. It is particularly applicable to bulked continuous filament nylon carpeting or yarns.

The Eastern Colour Dyeing Machine and the Superba System both dye running yarns (single ends). Jets of liquor spray on to dish shaped centrifuges which spot the yarn.

6. T.A.K. System

Droplets on a carpet or fabric surface are produced by a doctor blade scraping against a roller which draws a film of liquor from a trough. The dye liquor film is divided by the doctor blade and sprayed into drops when the streams come in contact with oscillating brushes. Application quantity, spot size and density are variable. This system was designed for carpet dyeing but should be applicable to yarns.

7. Resist Printing

All the previously mentioned systems are suitable for resist styles. There is a negative form of the T.A.K. system whereby a blank bath or lighter colour is added to the darker (but unfixed) ground producing spots of lighter intensity.

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