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D03404

QUALITY CONTROL IN THE FINISHING OF FABRICS [1]
MADE FROM BLENDS OF COTTON
WITH MAN-MADE FIBRES

by

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IDENTIFICATION TESTS FOR FIBRES contd...

4. STAINING WITH SPECIAL DYES :

1	2	3	4	5	6	7	8	9
a) B A Y E R	Pale yellow green	Black	Blackish green	Pale yellow green	Bottle green	Black green	Yellow	Blue
b) C A L C O	Greyish olive	Dark greyish purple	Blackish brown	Dark bluish green	Yellow	Purple brown	Pale yellowish green	Medium grey
c) D E T E X - I	Blue	Pink	Rosy pink	Sky blue	Medium yellow	Pale gold orange	Pale pink	Pale brownish pink
d) D E T E X II	Purplish brown	Yellow brown	Olive	Antish brown	Orange brown	Red brown	Pale purplish brown	Pale olive
e) D U P O N T	Greyish green	Dark greyish purple	Blackish purple	Dark greenish blue	Dark orange	Brownish wine	Dull yellowish orange	Pale brown
f) G E I G Y	Pale grey	Navy	Navy black	Grey	Yellow green	Navy blue	Pale rose brown	Greenish grey

..2..

5. SOLUBILITY TESTS WITH REAGENTS:

	2	3	4	5	6	7	8	9
i) 8-9N HYDROCHLORIC ACID	Insoluble	Insoluble	Soluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble
ii) CONC. HYDROCHLORIC ACID	Insoluble	Insoluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Insoluble
iii) CONC. NITRIC ACID	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Soluble	Insoluble	Soluble
iv) 70% SULFURIC ACID	Soluble	Insoluble	Soluble	Soluble	Soluble	Soluble	Insoluble	Soluble
v) 5% POTASSIUM HYDROXIDE AT BOIL	Insoluble	Soluble	Decomposes into small fragments	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
vi) 40% POTASSIUM HYDROXIDE AT BOIL	Insoluble	Soluble	Soluble	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
vii) GLACIAL ACETIC ACID	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Soluble at boil	Insoluble	Insoluble
viii) FORMIC ACID	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Soluble	Insoluble	Insoluble
ix) ACETONE	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble	Insoluble
x) CYCLOHEXANONE AT BOIL	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble	Insoluble
xi) DIMETHYLFORMAMIDE AT BOIL	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Insoluble	Soluble	Soluble
xii) METHYL SALICYLATE AT BOIL	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Soluble	Soluble	Insoluble
xiii) PHENOL	Insoluble	Insoluble	Insoluble	Insoluble	Soluble	Soluble	Soluble in hot	Insoluble

tests for fibres together with the performance characteristics of different fibres during these tests.

Quantitative chemical analysis of mixtures of fibres is based principally on the different solubility characteristics of fibres making it possible to dissolve out completely one of the components of the fibre blend leaving the other unaffected. In the quantitative analysis of the fibre blends, therefore, an accurately weighed representative sample of the blend fabric (or yarn) is treated with a selected solvent for one of the components under prescribed conditions, the dissolved out component separated from the residue by filtration, washing etc. and the residue determined by accurate weighing. This procedure enables the relative proportions of the different component fibres in a blend to be determined accurately. Table III gives the solvent, conditions of solution and other relevant information for the four fibre blends mentioned earlier as most commonly used with cotton.

PROCESSING OF COTTON-POLYESTER BLEND FABRICS

GENERAL:

It is advisable to have a thorough inspection of the loom-state fabric particularly in respect of soiling and oil stains. Removal of such defects at later stages becomes difficult, if not impossible, with these fabrics. Several stain removers are commercially available. The stain portion is spotted with the stain remover, steamed with a steam-gun and finally cleaned with detergent solution

TABLE III

Nature of Blend	Fibre to be dissolved	Solvent	Conditions of dissolution	Reference
Cotton-Polyester	Cotton	Mixture of sulphuric and glacial-acetic acid	$50 \pm 5°C$ for one hour	IS: 3416-1966
Cotton-polyamide	Polyamide	80% formic acid	Room Temperature; 15 to 20 minutes	IS: 2005-1962
Cotton-acrylic	Acrylic	Dimethyl formamide	$90°C$; 1-1/2 hours	IS: 3421-1966
Cotton-viscose	Viscose	Sodium-zincate	Room Temperature; 20 minutes	IS: 1389-1962

and water.

BLEACHING AND FINISHING:

While the processing of cotton-polyester blend fabrics is essentially similar to that of all-cotton fabrics, certain modifications in processing conditions and special treatments are required to get desirable processing quality and fabric properties. The discussion here will therefore be confined to the specific changes in the cotton finishing routine which are necessary.

The sequence of operations in finishing of cotton-polyester blend fabrics will depend on the quality of the fabric and the nature of the finish required. Typical sequences are given below:

1. **Polyester/cotton, finished white:**

    (a) Desize, Scour, Mercerise, Heat-set, Brush and Crop (if machinery is available), Singe, Heat-treat (anti-pilling, if required), Bleach, Apply fluorescent brightening agent, Stenter or carry out compressive shrinkage.

    (b) Desize, Scour, Mercerise, Bleach, Heat-set, Brush and Crop (if machinery is available), Singe, Heat-treat (anti-pilling, if required), Scour, Apply fluorescent brightening agent, Stenter or carry out compressive shrinkage.

Sequence (b) should be adopted for fabric which is badly stained with oil and dirt, the bleaching process aiding in

the production of a clean fabric before heat-setting.

2. Polyester/cotton, piece dyed:

    (a) Desize, Scour, Mercerise, Heat-set, Bleach (if necessary), Dye, Brush and Crop (if machinery is available), Singe, Heat-treat (anti-pilling, if required), Scour, Stenter or carry out compressive shrinkage.

    (b) Desize, Scour, Mercerise, Bleach, Heat-set, Dye, Brush and Crop (if necessary machinery is available), Singe, Heat-treat (anti-pilling, if required), Stenter or carry out compressive shrinkage.

Sequence (b) should be used for dirty loom state fabrics.

3. Polyester/cotton, printed:

Fabrics should be processed by sequence 1, the printing processes being inserted immediately prior to compressive shrinkage.

DESIZING:

Most size mixings are combinations of the following:

    (a) Film forming material -- (i) Natural base: Starch, modified starches such as hydroxyethyl starch, carboxymethyl cellulose (CMC), and natural gums; (ii) Synthetic base: Acrylic polymers, polyvinyl alcohol etc.

    (b) Lubricants -- Wax or self-emulsifying wax, tallow or water dispersible oils.

The objective of desizing is to remove the sizing materials as completely and uniformly as possible. A trace of residual size can usually be tolerated, but if present in large amounts, or if irregularly distributed, it can lead to such difficulties as (a) irregular dyeing, (b) stiff or variable hand, (c) varied response to thermosetting resin, and (d) reedy appearance of blends. Accordingly, desizing is an important step, and should be given the attention it deserves.

The size mixings used for cotton polyester blend warp yarns differ from those used for cotton warps primarily because of the hydrophobic nature of the polyester fibre and of the greater need to suppress, through sizing, yarn hairiness which is more pronounced with the blend yarns. The size mixing must provide good adhesion to the yarn and satisfactory film forming while maintaining the desirable tensile properties of the yarn. The size mixings for cotton-polyester warps generally contain a water-soluble starch derivative such as hydroxyethyl starch, sodium carboxy methyl cellulose, polyvinyl alcohol and a lubricant such as wax or self-emulsifying wax, tallow or water dispersible oils.

The following points should be kept in mind to achieve maximum desizing efficiency:

(1) Wetting agents added to the desizing solution to promote penetration of the enzyme into size films often tend to reduce the heat stability of the enzyme and thus

inactivate it. Non-ionic surfactants generally do not have such an adverse effect on enzymes. (2) Sometimes hydrocarbon solvents such as xylene are emulsified in the desizing bath to facilitate removal of the waxy component of the size. While none of the common solvents has an adverse effect on the enzymes, the emulsifiers used for dispersing the wax solution may affect heat stability of the enzymes and should therefore be selected carefully. (3) pH during desizing should be 6 to 7. Size additives such as acrylic copolymers may give as high pH as 9 to 9.5 depending on their sodium carboxylate content. The enzyme will be inactive at such a high pH. In such cases, the fabric may be neutralised prior to desizing or acetic acid may be added to the desizing bath. (4) Presence of copper or of high chlorine content in the water used can also inactivate enzymes.

The desizing procedure used will naturally depend on the nature of the size to be removed. If the starch derivate used is not water soluble, desizing will be with an enzyme plus wetting agent followed by an alkaline scour. On the other hand, if the size contains only an acrylic copolymer or CMC or a water soluble starch derivative, desizing will ordinarily require a warm water wash or a mild alkaline scour.

Enzyme desizing can be carried out by the pad batch or pad steam method or in a jigger or a kier. If after impregnation with a desizing solution, the fabric has to be steeped in

bins or batched on rolls, care must be taken to see that the fabric does not dry out since dry size residue is difficult to remove and will result in resist spots or streaks in final dyeing. This precaution is particularly important for the cotton-polyester blend fabrics since they hold much less moisture than all-cotton fabrics.

SCOURING:

The main precaution in scouring is to avoid or minimise the deleterious effect of alkali on the polyester fibre. The effect of caustic soda on polyester fibres is related to the temperature, concentration and time of treatment. For example, a 3% solution of caustic soda has no noticeable effect on the fibre if the treatment is at $70^{\circ}C$ for 90 minutes. On the other hand, at $100^{\circ}C$, the safe period for treatment is only 15 minutes. It is preferable to use soda ash instead of caustic soda for scouring and excellent results are obtained by scouring the blend fabrics on a jigger with a 4% solution of soda ash and 1% surfactant at boil for 3 hours.

MERCERIZING:

These fabrics are mercerised only to improve the cotton component with respect to luster, smoothness, dye affinity, coverage of immature fibres, higher chemical reactivity etc. Under the conditions normally used for mercerising cotton, there is practically no danger of damage to the polyester fibres. In view of the much lower absorption of aqueous reagents by the blend fabrics, partly due to the

hydrophobicity of the polyester and partly to the mild scouring received by the cotton, special penetrants of the non-cresylic type are required in the mercerising solution. Caustic soda solution of $42^{\circ}TW$ is generally recommended for mercerizing. The fabric after mercerising is neutralized to a pH of about 6.

HEAT SETTING:

This is a special finishing treatment required in the processing of cotton-polyester blend fabrics because of the basic structure and properties of the polyester fibre. In the manufacture of polyester filament, the molten polymer, after extrusion through a spinneret, solidifies to the filament on emerging in air and is collected on a bobbin. Yarn in this form is unoriented and lacks textile qualities. The filament is therefore drawn in a subsequent process which produces significantly better orientation of the polymer molecules in the yarn and gives high strength. Such a yarn shrinks considerably when exposed to high temperatures. Fig. 1 shows the amount of shrinkage of typical polyester and nylon yarns at different temperatures.

In view of this property of polyester, it is necessary to improve the dimensional stability of fabrics made from it so that they retain their shape during washing and ironing. This is achieved through heat setting. Apart from dimensional stability, heat-setting also imparts a better resistance to creasing and helps to remove creases formed during earlier processing steps and to avoid the
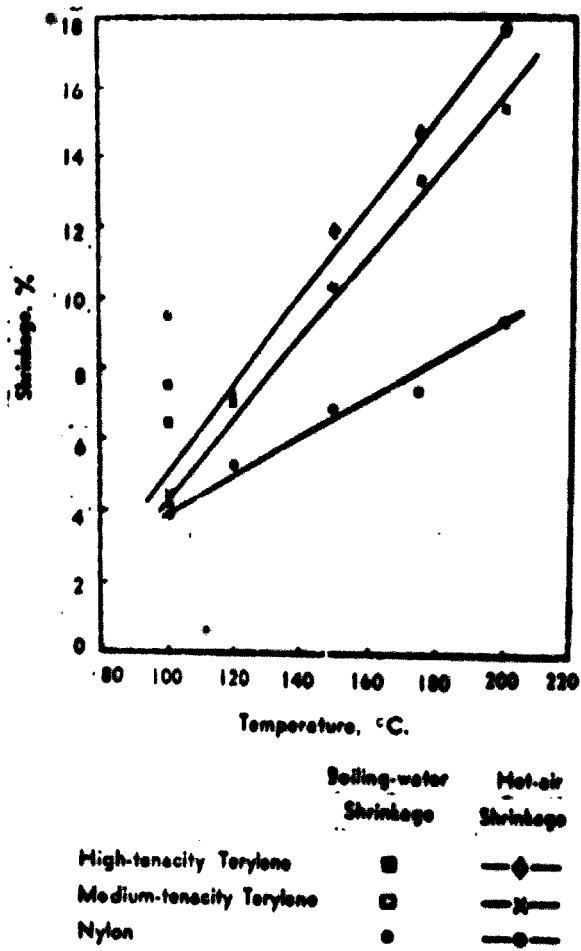
FIG. 1

Shrinkage of Terylene and Nylon Yarns in Hot
Air and Boiling Water (Marvin, J. Soc. Dyers
Col., 1954, 70, No.1, 16)

formation of creases in subsequent finishing. In principle, the process of heat-setting consists in exposing the fabric, while under dimensional control, to a temperature higher than that likely to be met with in its subsequent use. The energy supplied to the fibre in the form of heat during the setting process leads to a breaking of several inter-molecular hydrogen bonds and permits the fibre structure to relax and reach a state of minimum potential energy. If at this stage, the supply of energy is stopped and the fibres are cooled quickly, the fibre structure in its relaxed condition and with the new configuration of hydrogen bonds will be "frozen". In other words, the fibre will be dimensionally stable and will not shrink below the setting temperature.

Heat setting can be accomplished by using dry heat, aqueous heat, infra red radiation or by thermal shock. Of these, use of dry heat is the most widely prevalent method for heat setting today. The fabric is subjected to dry heat in a stenter or a curing chamber at $180^{\circ}C$ for 30 to 40 seconds. In Fig. 2 is shown the effect of setting temperature on dimensional stability of the fabric. It can be seen that the higher the setting temperature, the lower is the residual shrinkage of the fabric. Fig. 3 shows the amount of fabric shrinkage at different temperatures after it is set at temperatures varying between 120° and $220^{\circ}C$. These data show that a fabric will have a residual shrinkage less than 1% if it is set at a temperature 30° to $40^{\circ}C$ higher than that at which it is required to be stable. Furthermore,

Fig. 3

Effect of Setting Temperature on Dimensional
Stability of Fabrics (Marvin, J.Soc.Dyers.
Col., 1954, 70, No. 1, 16).
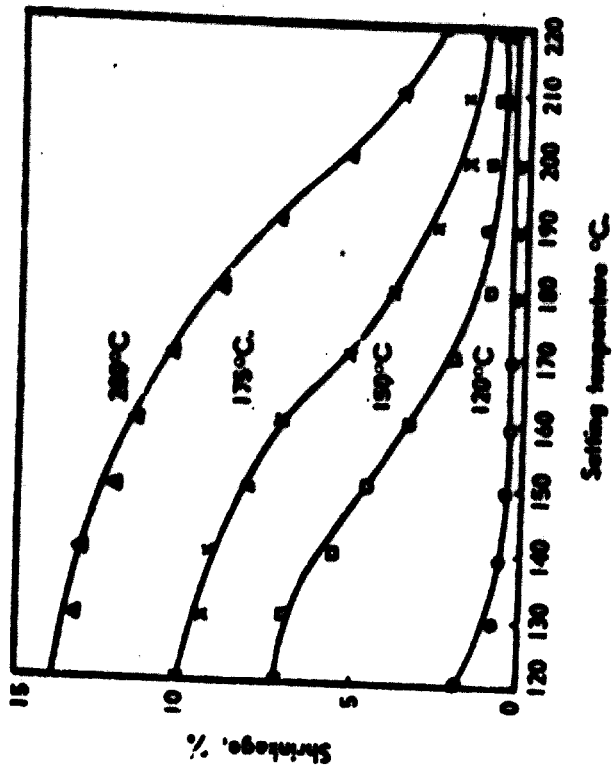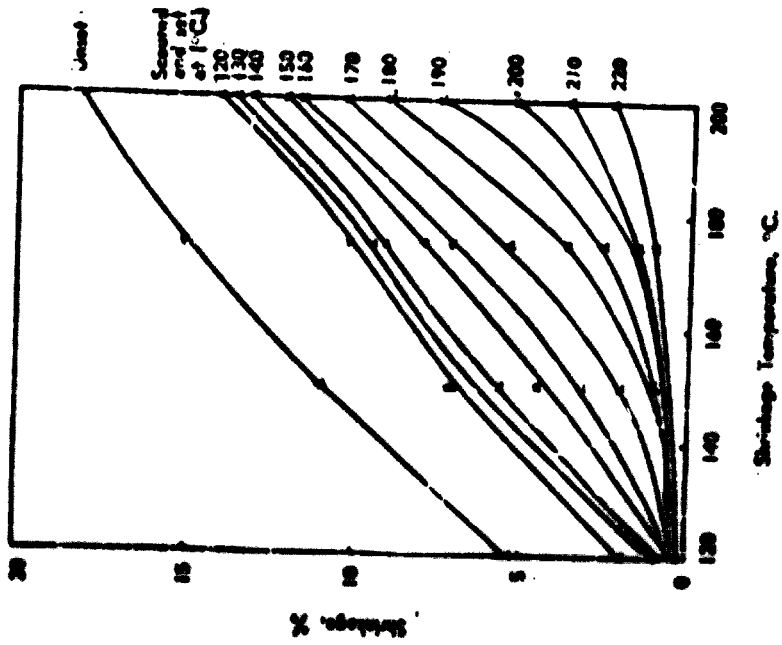

FIG. 2

Shrinkage of Terylene (Set with Hot-Air) at diffe-
rent Temperatures (Marvin, J.Soc.Dyers Col., 1954,
70, No. 1, 16)

no significant advantage in stability is gained by using a higher setting temperature than this.

Besides dimensional stability, the process of heat setting also influences other fabric properties. The tendency of the fabric to crease during washing or boiling is reduced. Also, creases in the set fabric are readily removed on ironing. Heat setting stiffens the fabric and adversely affects its handle and drape. Fabric stiffness increases with increasing the setting temperature. Dry crease recovery of the fabric decreases rapidly at setting temperatures beyond 170°C.

The handle and crease recovery properties of fabrics set at temperatures up to 220°C can be restored by treatment with caustic soda on the jigger followed by calendering. The dye uptake of the fibre decreases with increasing temperature of heat setting, the lowest dye absorption being at about 175°C (Fig. 4). Thus, it can be expected that variations in the heat setting temperature will lead to uneven dyeing. It is interesting that if setting is carried out in the temperature range 220° to 250°C, i.e. much above the recommended temperature, there is a sharp increase in dye absorption. This temperature range, however, cannot be utilised commercially because small difference in the temperature of heat setting produces large difference in dyeability. Consequently, the commercial practice is to heat set polyester-cotton fabrics at 180°C for 30 to 40 seconds allowing 1 to 2% shrinkage in both warp and weft directions.
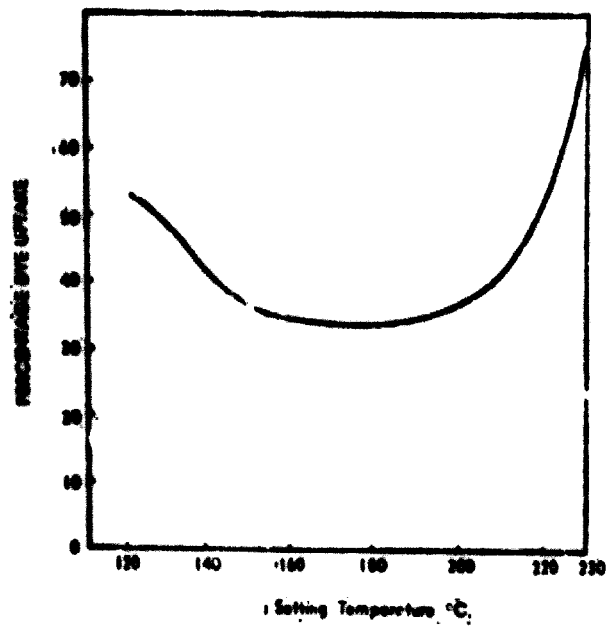
FIG. 4

Effect of Setting Temperature on the Dyeing of Terylene
Fibre (2.0% Dispersol Fast Scarlet B 150 Powder Fine at
100°C for 90 minutes).

In addition to temperature, variations in moisture, tension and time of treatment during heat setting also cause variations in the dyeing properties of the fibre. The dyeing method also plays an important part in determining the extent of variations in the dyeability caused by these factors. Heat setting prior to dyeing has no noticeable effect on dyeability when the thermosol process is used for dyeing.

Use of aqueous heat (high pressure steam) is not recommended because of the danger of degradation of the polyester fibre.

Infra red radiation of 3 to 3.5 μ is practically completely absorbed by the polyester fibre. Selective emitters which emit radiation with a pronounced maximum in this region have now been developed. With such selective infra red emitters, heat setting can be effectively carried out at fabric temperatures between 80° and 120°C.

Heat setting by thermal shock process has been developed in U.S.A. for setting the dyed fabrics and thus to avoid difficulties of dyeing these fabrics after heat setting. This process uses infra red burners with temperatures of 640° to 760°C for one second (fabric temperature 200° to 215°C) and offers two important advantages, viz. negligible sublimation of dyes and high working speeds. However, energy consumption is high and it is difficult to get reproducible results. The process appears to be suitable only if large yardages of standard fabric qualities are to be set. Heat setting can be carried out at different stages

of processing, as shown in Table below :

A. Loom State	B. Intermediate	C. After-Setting
1. Heat-Setting	1. Desizing	1. Desizing
2. Desizing	2. Scouring	2. Scouring
3. Scouring	3. Mercerising	3. Mercerising
4. Mercerising	4. Drying	4. Bleaching
5. Bleaching	5. Heat-setting	5. Dyeing
6. Dyeing	6. Bleaching	6. Drying
7. Drying	7. Dyeing	7. Brushing & Cropping
8. Brushing & Cropping	8. Drying	8. Singeing & Washing
9. Singeing & Washing	9. Brushing & Cropping	9. Drying
10. Drying	10. Singeing & Washing	10. Heat-setting
11. Heat-treat (Anti-pilling)	11. Drying	11. Heat-treat (anti-pilling)
12. Scouring	12. Heat-treat (anti-pilling)	12. Scouring
13. Drying	13. Scouring	13. Drying
14. Finishing (Compressive shrinkage etc.)	14. Drying	14. Finishing (Compressive shrinkage etc.).
	15. Finishing (Compressive Shrinkage etc.)	

The relative advantages of these three sequences are shown in Table IV.

Heat setting is normally carried out on the pin stenter setting machine which is similar to the conventional pin stenter, but can operate at temperatures of 260°C. After leaving the stenter, the fabric is shock-cooled with cold air or by passing over water cooled drums at the delivery end. Heat-setting in a stenter has the advantage that the fabric is maintained under complete dimensional control during drying and setting. A uniform width for fabrics is thus ensured.

TABLE IV

RELATIVE ADVANTAGES AND DISADVANTAGES OF SETTING AT DIFFERENT STAGES

A. Loom State	B. Intermediate	C. After-setting
Size and impurities are fixed by heat treatment which cannot be removed in subsequent operations.	No fixation of size and impurities.	No fixation of size and impurities.
Woven goods cannot shrink freely before heat-setting. All dyes can be used.	Fabrics can shrink sufficiently before heat-setting.	Fabrics can shrink sufficiently before heat-setting.
	All Dyes can be used.	Only dyes fast to sublimation can be used. Otherwise, shade changes with dyes of poor fastness to sublimation.
The yellow colour due to heat-setting can be removed by bleaching.	The yellow colour due to heat-setting can be removed by bleaching.	The yellow colour due to heat-setting cannot be removed any more by bleaching.
The fabric is set before undergoing any of the wet processing steps and is therefore less sensitive to wrinkling. Therefore, there is very little crease formation during dyeing.	One additional drying operation required.	The fabric is in unset condition during all the wet processing operations and is therefore very sensitive to wrinkling.
	The fabric is in unset condition during some of the first wet processing steps and is more sensitive to wrinkling during these processes. However, there is very little crease formation during dyeing as setting is carried out before dyeing.	
Heat-setting improves the resistance to slipping. The risk of slipping during wet operations is, therefore, reduced.	Tendency to slipping is greater during some of the first wet processing steps.	Tendency to slip is greater in all wet operations.
Irregular dyestuff uptake if setting is not carried out uniformly.	Irregular dyestuff uptake if setting is not carried out uniformly.	Dyestuff uptake not affected.
Residual carrier remains in the fabric.	Residual carrier remains in the fabric.	Any residues of carrier are removed.

An automatic fabric overfeed mechanism ensures controlled
shrinkage in the warp direction. Fluctuations of
temperature within the stenter must not exceed $\pm$ 1°C.
Supply of air at even speed over the entire width of the
fabric is assured by special arrangements of air ducts,
nozzles and air discharge and by careful insulating of
the stenter. Stenters used only for setting have only
a light pin chain whereas those used for both drying
and setting have a combined pin and clip chain. The
heavy chains of such a stenter absorb and conduct too
much heat with the result that the fabric in contact with
the chains will not be heated as much as the rest. There
may also be a temperature gradient from the centre of the
piece to the selvedges leading to the selvedge dyeing
light. The fabric may also become wavy in subsequent
operations. It is customary to provide chain heaters so
that the chain temperatures equal air temperatures inside
the stenter.

Resin curing ovens can also be used for heat setting.
Since there is no special means of width control, the
set width of the fabric will depend upon the cloth con-
struction, framed width and setting temperature. Accurate
determination of temperature within the oven is usually
difficult and a difference of 10° to 20°C between the
temperature indicated by the thermometer and the actual
temperature within the oven is not uncommon. Setting can

also be carried out on hot-metal cylinders or by a combination of cylinders and hot air. The main disadvantages of these setting machines is the absence of a close control of weft dimensions.

The degree of setting effect obtained can be determined and controlled by the following tests:

(a) Shrinkage test (Du Pont Boiling Method): A square is drawn onto the set material and measured. The material is boiled in soft water in the washing wheel for 30 mins., centrifuged and air dried without ironing. The dimensions of the square are measured and the shrinkage determined.

(b) Determination of the creasing angle before and after setting.

(c) Assessment of handle before and after setting.

ANTI-PILLING TREATMENTS:
Pills are small balls produced by the entanglement of protruding fibres which develop on the surface of a fabric during wear and washing. In case of garments made out of strong fibres such as polyester, such pills are tenaciously anchored to the fabric surface and do not wear off easily. Pills do not affect durability but do spoil the appearance of a garment and are therefore undesirable.

The tendency for pilling decreases with increase in fibre denier. Fibres with round cross sections tend to pill the most whereas those with dumb-bell or serrated cross-sections have much less tendency for pilling. Finer yarn count as well as plying of yarns (normally doubling) help to reduce pilling considerably. Adequate twist levels in the yarn are also very important in controlling pilling. Twist multipliers in the range of 4 to 4.5 for single yarns are found to be satisfactory. With plied yarns it is desirable to keep the single yarn twist at a normal level but increase the ply twist. Regularity of yarn is extremely important in controlling pilling, thick and thin places being particularly susceptible to this kind of defect. Similarly yarn hairiness will also encourage pilling and has to be minimised. Loose and open knitted fabric structures are more prone to pilling than firm woven structures. Plain weaves are more pill resistant than twills or other types of weaves with floats. High cover factor is also important in reducing pilling.

Having taken maximum advantage of yarn and fabric construction to minimise susceptibility to pilling, control of this defect is ultimately achieved through appropriate finishing treatments. Singeing is one of the most effective methods. The fabric is first given a brushing treatment on a cylindrical rotary wire brush which moves in the opposite direction to the fabric at speeds about 60 times faster than the fabric. The wire brush lifts
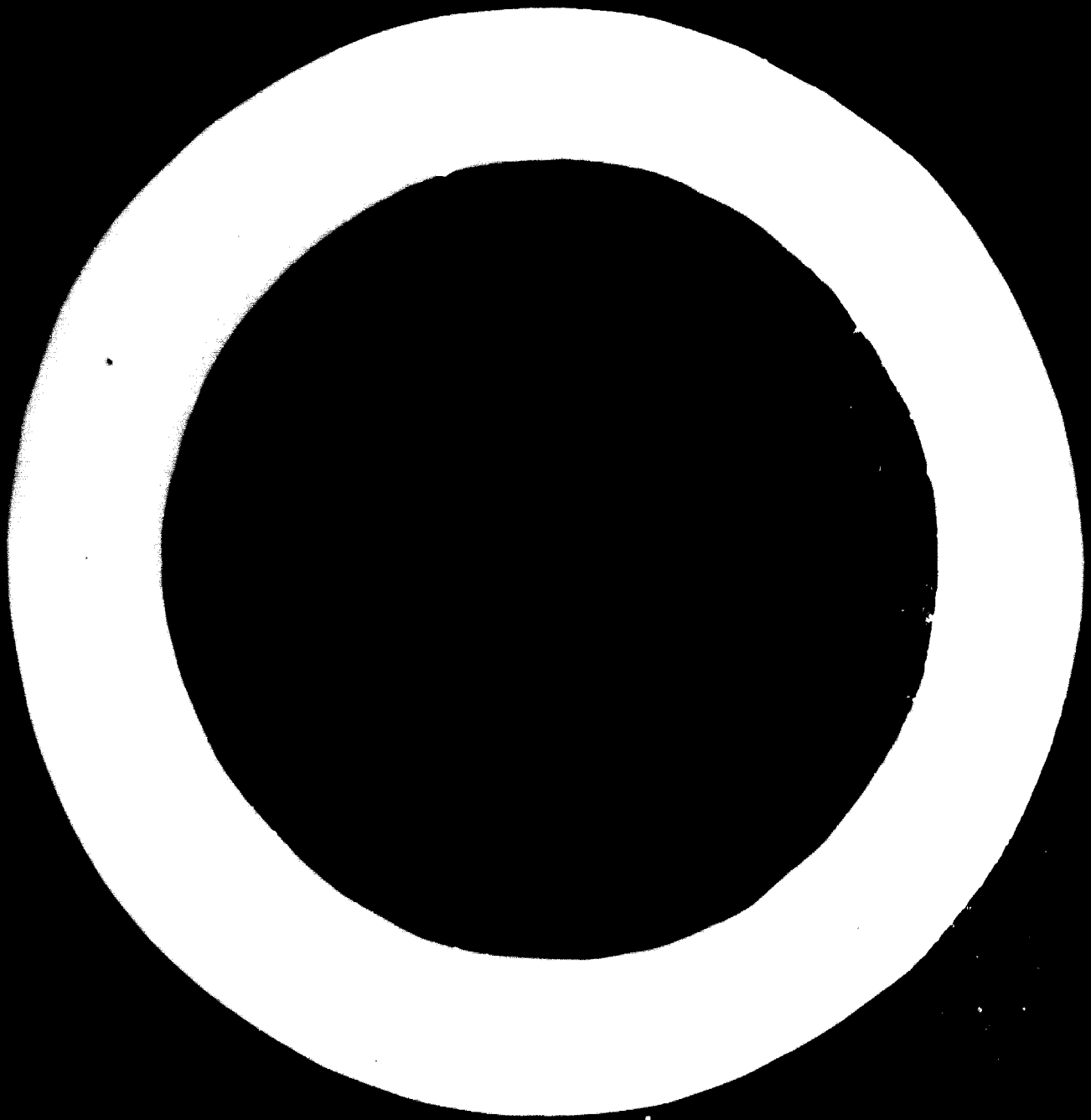
the individual fibres from the surface of the fabric
and these fibres are then sheared in a conventional
shearing machine. This is then followed by singeing.
If dyeing follows singeing, the tiny melted balls of
the singed fibres on the surface of the fabric dye
deeper than the rest of the fabric and produce
undesirable speckled appearance. Also any heat diffe-
rences in singeing across the width of the fabric can
show up as shading in subsequent dyeing. Wherever
possible, therefore, singeing should be done after
dyeing. However, if thermosol method of dyeing is
adopted, singeing can precede dyeing.

It is preferable that in singeing the fabric travels
past atleast two singeing flames at speeds of 100 to
150 metres per minute. If required, brushing, cropping
and singeing can be repeated several times. After
singeing it is essential to wash the fabric intensively
in open width with a detergent at 40° to $50^{o}C$ to remove
the smell and dust of burnt fibres from the fabric.

Another method to reduce pilling is heat setting. In
fabrics such as twills made from single yarns, and those
containing long floats, there is some chance of fibres
coming out of the fabric surface even after brushing,
cropping and singeing. In such cases, a heat treatment
more severe than used for setting effectively reduces
the pilling tendency of the fabric. Treatment at $160^{o}C$
for 5 minutes in baking ovens or at $180^{o}C$ for 2 minutes

in a hot air stenter completely eliminates pilling. Such a treatment is most conveniently carried out after singeing but before washing.

Chemical means have also been recommended for controlling pilling. For example, the PEG process of Du Pont (Modern Textile Magazine, 1957, 38, No.9, pp.82) involves padding of the desized and scoured but undyed fabrics with polyethylene glycol followed by drying and then curing at 220°C on a contact heat setting machine. It is claimed that on many fabric styles this treatment eliminates the need for singeing. However, the major drawback of the process seems to be that it enhances the sensitivity of the polyester fibres to differential dyeability on heat setting. The process is therefore best restricted to white fabrics or to those blend fabrics where only the cotton component is dyed.

TESTING FOR PILLING TENDENCY OF COTTON-POLYESTER BLEND FABRICS:

The tester consists of a rotating box (inside measurements 205 x 205 x 205 mm) lined with layers of cork 3 mm thick whose surface is constantly renewing as it wears. The wooden box is mounted on a rotatable stand rotating at a speed of 60 ± 1 r.p.m. Four test samples 5" x 5" are cut and sewn into sleeves which will just fit soft rubber tubes 6" long 1¼" o.d. and 1/8" wall thickness. The sleeves are turned inside out so that the seams are on the inside and the samples are secured

at the ends of the tubes with cellophane tape. Four
pieces of rubber tubes with cloth to be tested and
four tubes without cloth are rotated in the wooden
box for 5 hours (in some cases time is 10 hours).
After tumbling, the samples are removed and the extent
of pilling is assessed visually by comparison with
arbitrary standards on a 3-point scale. Where the
pill ratings are to be used in plotting curves, it is
convenient to assign a numerical value by counting the
pills per unit area.

BLEACHING:

In polyester-cotton blend fabrics, normally only the
cotton component requires to be bleached. If the
goods are to be marketed white, the polyester component
also requires bleaching. Bleaching of the polyester
also becomes necessary if sighting colours are used
or if the polyester has turned yellow during heat
setting. Of the three bleaching agents, sodium chlorite,
hydrogen peroxide and sodium hypochlorite, the first
gives the most satisfactory results. However, it
involves problems of corrosion and of toxic fumes of
chlorine dioxide. Addition of 1 to 2 g/l of sodium
nitrate (and similar proprietary auxiliaries) to the
chlorite bleaching bath minimises corrosion and reduces
the objectionable smell of chlorine dioxide. A single
stage combined scouring and bleaching process such as
Du Ponts solomatic process can also be used successfully.
The desized fabric is mildly scoured, then saturated in

an alkaline peroxide solution and subsequently stored
hot in the single stage J-box where bleaching takes
place. The temperature in the J-box can be from 75° to
100°C.

A typical process sequence is given below:

1. The fabric is singed and then watted out with 2.5 g/1
   of surfactant and 1.7 g/1 of trisodium phosphate at
   65°C.

2. It is then washed at 70°C and saturated at 35°C in
   a bath containing 31 ml/1 of 35% hydrogen peroxide,
   12 g/1 sodium silicate (42°Be), 4 g/1 caustic soda
   flake and 2 g/1 borax decahydrate.

3. The fabric is then heated at 95°C and stored in
   the J-box for 75 minutes after which it is washed
   at 65°C and dried. If the fabric contains dyed
   threads, it is bleached at 80°C instead of 95°C.

With hypochlorite only moderate bleaching effect can be
obtained.

Application of Optical Brightening Agents (OBA):
Since the optical brightening agents used for cotton
have no affinity for polyester, two entirely different
agents are required - one for polyester and the other
for cotton. Very few OBAs for polyester are available
today. These can be applied either by the exhaustion
method or the pad bake method. With some OBAs such as
Uvitex ERN conc. application can also be carried out in

the presence of a carrier at 80° to 90°C.

The OBAs used for polyester get deposited mechanically on the cotton fibres and will therefore dull the brightening effect of the OBAs used for cotton. Hence the fabric has to be given an intermediate clearing treatment with hydrosulfite to remove the OBA for polyester from cotton. The cotton component is treated with suitable OBAs in the usual manner.

OBAs for both polyester and cotton can also be directly applied in the resin finishing bath. The heat treatment following resin impregnation develops the brightening effects on both cotton and polyester. This process is economical but the brightening effect obtained is not very intense.

FINISHES FOR DIMENSIONAL STABILITY:

Although heat setting imparts dimensional stability to the polyester component it does not completely compensate for the shrinkage of the cotton component in washing. The heat set fabric can have as much as 4% residual shrinkage. Therefore, the classical methods for controlling dimensional stability of cotton such as mercerising, compressive shrinkage and resin treatment are employed on polyester-cotton blend fabrics. Resin finishing is not absolutely necessary for polyester-cotton blend fabrics which already have good wash-and-wear properties, but is employed to further enhance these properties. The formulations used are similar to those

employed for cotton but with lower resin concentrations.

PERMANENT PRESS (PP) FINISHES:

The polyester-cotton blend fabrics are ideally suited for producing PP garments. The most widely used processes for PP finishing are the deferred cure, fibre modification and post (or pressure) cure methods. In the deferred cure processes, the fabric impregnated with an appropriate cross linking agent, catalyst and other finishing agents is dried but not cured. Excessive cross linking is avoided at the drying stage. The so-called sensitised fabric is made up into garments which after the desired setting of shape, creases, pleats, etc. are cured in a baking oven. In the fibre modification process, a reactant of the non-volatile sulphone type ($XCH_2CH_2SO_2CH_2CH_2X$, where X is NaO_3SO-, NaS_3SS-, $CH_3CO_2-C_5H_5N_+-$etc.) is applied to the fabric. After drying the fabric is treated with aqueous sodium hydroxide and batched. Subsequently, fabric is washed and then padded with 1 to 2% of potasium bicarbonate (on the weight of the fabric) together with lubricants and other finishing agents and dried. Garments are made from such a fabric and after shaping creases are set in by curing for 3 to 15 minutes at 165° to 120°C. In the post-cure process, the fabric is given the conventional wash-and-wear finish including the full cure. The garments made from such a fabric are pressed and cured simultaneously using special presses which
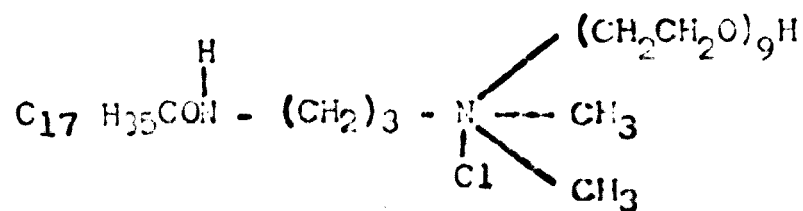
very high temperatures and pressures.

ANTI STATIC FINISH:

Textile fibres in dry condition are electrical insulators. The fabrics therefore become electrically charged when they come into frictional contact with insulated parts of machines or when they rub against each other. The static electricity so generated can seriously interfere with textile processing. Also, due to this electrostatic charge, the fabric readily attracts soil and also causes discomfort to the wearer by clinging too tightly to the body. With polyester-cotton blend fabrics, the discomfort is considerably minimised because of the hydrophillic nature of cotton. Anti-static after-treatments are therefore not essential in such blends but are sometimes required to minimise the difficulties in processing of these fabrics particularly when the fabric comes out of the machine in a very dry condition in processes such as heat setting and thermo-fixation.

The most common method for minimising accumulation of electro-static charges is to apply a chemical anti-static finish which increases the electrical conductivity of the textile material and thus helps to dissipate the charge from the localised points of charge formation on to the whole surface of the fabric. Many modern antistatic agents are quaternary ammonium compounds containing a pentavalent nitrogen atom to which one

ionizable group such as halogen or sulphate is attached.
A typical example of such an agent is:

$$C_{17}H_{35}CON - (CH_2)_3 - \underset{\underset{Cl}{|}}{\overset{H}{N}} \begin{array}{l} (CH_2CH_2O)_9H \\ --- CH_3 \\ CH_3 \end{array}$$

Condensation products of ethylene oxide with either
organic alcohols and carboxylic acids or with aliphatic
and aromatic sulphamides are also found to be effective
antistatic agents. The molecular complexity of the
anti-static agent influences its behaviour on a fibre
during storage. The more complex the molecule, the
less loss of anti-static effect during storage. If the
anti-static effect is required to be durable to washing,
the treatment is applied at the finishing stage so that
there is no adverse effect due to the anti-static agent
on fabric dyeing. The deposition of cross-linked poly-
electrolytes on the surface of the fibre is a widely
used method for producing anti-static effects that are
durable to washing. Commercial antistatic finishes such
as Aston LT and Aston 108 are based on water soluble
polyamine resin cross linked with dihalides.

MEASUREMENT OF THE EFFECTIVENESS OF ANTISTATIC AGENT:

The effectiveness of the agent can be assessed (i)
by determining how the electrical resistance of a
textile material is lowered by the application of the
agent, (ii) by finding how the treated material accumulates

...tic charge in a rubbing test and (iii) by

...ck-up test.

... for determining the electrical resistivity

... ...olves holding eight strands of treated yarn

... ...two terminal clamps (of an ultrohmeter of the

...man instrument company) placed two inches apart and

measuring the electrical resistance in ohms. The

volume resistivity (ohms/cm) is given by the formula:

$$\text{Volume resistivity} = \frac{\text{Resistance x weight of fibre between clamps}}{\text{Density of fibre x (distance between clamps)}}$$

For a satisfactory antistatic treatment the volume

...sistivity should not exceed 5×10^9 ohm/cm.

... rubbing test consists in rubbing the treated textile

...rial ten times with a woollen cloth. The charged

... is immediately placed in a metal cup (insulated

...vent loss of charge) connected with a suitable

...er. The voltage reading then indicates the

...of electrostatic which is present on the textile

... . The indicated voltage should be below 300

volts for an efficient antistatic agent.

A dirt pick-up test is often employed for a quick

assessment of the effectiveness of an antistatic agent.

In this case, the treated fabric is rubbed ten times

...woollen cloth and held in position for ten

seconds one inch above an open container of synthetic

soil. The amount of the dirt attracted is estimated

visually and the grades are given as follows:

<div>

None   -   Excellent protection

Slight -   Good protection

Medium -   Fair protection

Heavy   -   Little or no protection

</div>

C.H.C. PROCESS:

This process, developed by Du Pont, improves the liveliness, drape and handle of both 100% polyester filament fabrics as well as polyester-cotton blend fabrics. The fabric, after scouring as usual, is calendered at 10 to 20 tons pressure at 95° to $175^{\circ}C$ at a speed of 15 to 20 yard per minute with one pass on each side. Calendering flattens the yarn and consequently increases the cover of the fabric. It also reduces fabric thickness making it light and airy. Heat setting is then carried out under standard conditions already described earlier. This is followed by treatment with a 3% caustic soda solution as follows: The fabric is entered into alkaline solution at room temperature. The temperature is then raised to $100^{\circ}C$ and treatment continued for 30 minutes. The bath is then cooled to $70^{\circ}C$ for 20 minutes and then dropped. The fabric is washed in cold water for 5 minutes, rinsed in a bath containing 2 g/l glacial acetic acid and finally washed and dried.

INTRODUCTION:

The textile manufacturer of today has a large variety of fibres to choose from for satisfying specific end-use requirements. Natural fibres such as cotton and wool which were known to man for several centuries were supplemented by rayons in the beginning of the twentieth century. Rayons are cellulosic in nature and are either natural cellulose in a regenerated form such as viscose and cuprammonium rayon, or chemical derivatives of natural cellulose such as cellulose acetate. In the last thirty years, several purely man-made fibres produced by synthesis of suitable polymeric compounds became available to the textile manufacturer. Of these, polyamides, polyesters, polyacrylics and polyolefins have assumed maximum industrial importance.

Each fibre type has distinctive properties which confer on it both advantages and disadvantages in terms of particular end-uses. For example, cotton has satisfactory strength, easy dyeability and high moisture regain which endows wearing comfort to cotton apparel. At the same time, it has poor elastic recovery, low to moderate abrasion resistance and a tendency to swell in water. Because of these fibre properties, cotton fabrics crease easily, have moderate wear-life and shrink during washing

DYEING OF POLYESTER COTTON BLEND FABRICS:

The dyeing of polyester-cotton blends whether carried out as one-bath or two-bath process proceeds as two distinct dyeing processes for the two fibres. Dyeing involves diffusion of the dye into the fibre and adsorption of the dye molecules on the fibre at specific sites. The compact physical structure of the polyester fibre results in extremely slow diffusion of the dye molecules into the fibre. Two methods are used on an industrial scale to increase the rate of dye diffusion within the fibre. These are (a) use of swelling agents and (b) use of high dyeing temperatures.

Certain chemicals such as diphenyl, o-phenyl phenol and its derivatives, p-phenyl phenol, chlorinated benzene (mainly dichlorobenzene), methyl salicylate, benzoic or salicylic acid increase the rate of dyeing of polyester fibres. These dyeing assistants, termed carriers, include both water soluble and insoluble compounds. Though the mechanism of action of carriers is not yet fully understood, the following mechanisms may operate during dyeing:

1. The carrier may form a complex with the dyestuff, significantly increase the solubility of the dye in the aqueous phase and hence increase the rate of diffusion of the dye into the fibre.

2. Water soluble carriers may diffuse more rapidly than the dye into the fibre, become attached to the fibre substance by van der Waal's forces, and then attract water into the fibre because of its hydrophillic groupings. The water swells the fibre and facilitates entry of the dye.

3. Hydrophobic carriers such as diphenyl or chlorobenzene cannot operate according to the above mechanism. They may, however, act as molecular lubricants and destroy existing intermolecular forces in the fibre, and thus facilitate diffusion of the dyestuff molecule into the fibre.

4. The carrier may have high affinity for both dye and fibre. Since it diffuses more quickly than the dye into the fibre and gets adsorbed on the fibre sites, it will offer new sites for the adsorption of dye molecules.

It is generally accepted that carriers assist dyeing by loosening the molecular structure of the fibre. Thus, their action is essentially similar to that of increase in temperature, the use of a carrier being approximately equivalent to a 10° to 20°C rise in temperature. It is possible that the action of a particular carrier may involve several of the mechanisms outlined above.

Carriers should be cheap, efficient, easily removable by washing, non-toxic, should not affect the shade or

decrease the fastness of dyes, should not volatilise from the dye bath and should be sparingly water-soluble but easy to emulsify or disperse. As a rule, the effectiveness of a carrier decreases as its solubility in water increases. Insoluble or sparingly soluble carriers must be finely dispersed or emulsified in order to avoid specky dyeings. Anionic dispersions are generally used though nonionic compounds can also be used.

Care must be taken to see that no "creaming up" of the carrier occurs during dyeing, when the dye bath or the dyed fabric is cooled. In such an event, re-emulsification is difficult and specky dyeings may result. Some carriers tend to volatilise and condense on the cooler portions of the dyeing machines, creating the risk of dropping on the goods and causing specks. Open steam pipes to blow steam into the space above the rollers should be provided to eliminate this danger. Residues of carriers after dyeing may impair fastness to light and washing, cause irritation to the skin and impart an unpleasant smell to the fabric. Residual carriers must be therefore removed by thorough washing after dyeing. Residues of easily sublimable carriers can be largely removed by a dry heat treatment at about 150° to $180^\circ C$ followed by treatment in alkali.

Use of carriers increases the cost of dyeing and lengthens the dyeing process. Also carriers are apt to cause spots

and give unlevel dyeing including skirting, tailing and side to centre shading. Complete removal of carrier is difficult and the residual carrier may affect light fastness of the dyeing. Some carriers are toxic, inconvenient to handle and have an unpleasant odour. Inspite of these disadvantages, carrier dyeing is still widely practised because it does not involve major modifications or additions to existing machinery in a process house.

USE OF HIGH DYEING TEMPERATURES:

Increase of dyeing temperatures not only increases the energy (and therefore rate of diffusion) of the dye molecules but also increases the mobility of the polyester molecule chains in the amorphous region of the fibre making the latter more accessible to the dye. Dyeing temperatures of $115^{\circ}-120^{\circ}C$ are achieved by using high pressure dyeing equipment. Pressure dyeing is widely used for dyeing yarn. For piece dyeing under pressure, pressure dyeing jigs and machines such as Barotor and HT Beam Dyeing machines are available. Piece goods can also be dyed by an alternative high temperature dyeing technique viz. the thermosol process. In this process, the fabric is padded through a dispersion of the dye, dried and then heated for about a minute at approximately $200^{\circ}C$. At this temperature, many disperse dyes are molten whereas the fibre is in a plastic state. Thermosol dyeing is therefore essentially a solution of the liquid dye in the fibre, also present as a viscous

liquid. Solubility of the dye in the fibre strongly depends on temperature. Hence the dye will tend to crystallise out of the solution when the fabric is cooled to room temperature. However, the dye cannot come out of the fibre since the dye molecules are almost completely unable to move through the fibre at room temperature.

HIGH TEMPERATURE DYEING FROM AQUEOUS BATHS IN CLOSED SYSTEMS:

The dye bath is prepared by adding the well dispersed dyestuffs together with a suitable dispersion agent and a buffer (acetic acid, ammonium sulfite, sodium acetate-acetic acid, ammonium sulfite-formic acid) to adjust pH to 5 - 5.5. The goods are entered at 60^0 to 80^0C and dyeing carried out at this temperature for 30 to 60 minutes. The goods are then rinsed and after-treatment.

High temperature pressure jigs are used mainly for heavier fabrics of 100% man-made fibre or their blends with cotton. Like normal jigs, HT jigs also exert pronounced lengthwise tension which can cause distortion of the fabric. Creases formed in these fabrics at temperatures higher than 100^0C can be fixed permanently. HT jigs must therefore have rollers which can be seen from outside, suitable expanders and controllable tension. The jig is closed only after the pieces have been run a few times free of creases. It is necessary that the fabric is heat set before dyeing in the jig. HT jigs are suitable for large or small jobs, permit a wide

variation in the liquor-ratio, are especially suitable
for medium weight fabrics, occupy comparatively less
floor space and are easy to operate. However, they
involve the risk of formation and fixation of creases
in the fabric, are expensive, can operate only batch-wise
and give slow rates of production.

The HT Beam dyeing machine is similar to a horizontal
kier and can accommodate either a single large diameter
beam (batch size about 3500 yards) or 3 to 6 small
diameter beams (batch size per beam about 300 yards).
While the machine has arrangements for reversible
flow of dye liquor, most of the fabrics can be dyed
satisfactorily with inside-out flow only. For tightly
woven fabrics, however, reversing the flow may be
necessary.

In HT beam dyeing, fabrics with high potential shrinkage
must be first boiled off or set to give a beam of
constant tenacity throughout the dyeing and a final fabric
of good dimensional stability. For satisfactory results,
a cotton leader must be tightly wrapped round the beam
before batching the fabric to be dyed. The fabric
should be batched wet or damp to reduce the possibility
of air getting entrapped in the batch during the dyeing.
Creases and folds in the fabric should be avoided during
batching. The fabric batch should overlap the perfora-
tions on each end by about 1-½ to 2".

The dye bath is set at 40°C with 1000 parts of water,

0.75 part of dispersing agent and 0.5 part of non-ionic
wetting agent and the dyestuff dispersed according to
manufacturers instructions and added through a sieve.
Dyeing is started with the liquor flow inside out.
The system is then closed to the atmosphere and the
temperature raised to 130°C in 30 minutes. While the
temperature is raised, the system must be maintained under
static pressure to prevent cavitation in the pump and any
air entrapped in the dyeing chamber must be vented out.
Dyeing is continued at 130°C for 40 minutes after any
shading additions that may be necessary are made. At
least 15 minutes of dyeing are allowed after each such
addition. When the dyeing is complete, the batch is
dropped without prior cooling provided the exhaust pipe
from the dye vessel and the drains are suitably construc-
ted. Dropping the bath when cooling gives cleaner dyes
with a good rubbing fastness since it avoids the formation
of dye crystals on the fabric surface.

HT Dyeing considerably shortens dyeing time and gives
high exhaustion resulting in saving of dyestuffs and
chemicals. HT dyeings are more level and have better
fastness to washing, crocking and sublimation as compared
with carrier dyeing.

THERMOSOL PROCESS:

The Du Pont Thermosol Process was developed in 1949 but
has been widely used only in recent years. Being a
continuous process large yardage in a given shade is

necessary for economical dyeing. Dyeing by this process
is relatively simple and consists of a padding of the
fabric with (a) appropriate dye stuff, (b) drying the padded
fabric, (c) fixation of the dye stuff within the fabric .
by means of heat and (d) after-treatment including dyeing and
development of the other component fibres in a blend
fabric. Besides high rates of production, the thermosol
process gives excellent dye utilisation, does not require
previous heat-setting and permits simultaneous dyeing and
heat setting even of heavy weight goods.

The polyester cotton blend fabrics must be efficiently
prepared for successful dyeing by this process. High
absorbency of the cotton component must be obtained.

The standard thermosol equipment consists of a padder,
a predryer, drying cans or hot flue, a thermosol oven and
a chemical pad unit, a steamer, an open soaper containing
10 wash boxes and drying cans. With such an equipment a
full range of shades can be dyed on the blend fabric with
a wide range of dye stuff types. In the absence of a pad
steam range it is possible to dye the polyester on a pad
dry thermosol range and then dye the cotton on the jig
with vat dyes. The thermosol range can also be split into
two units, one for padding and drying and the other for
curing. This would permit processing of smaller lots
which after padding and drying could be stitched together
and heat treated in one long run. The exact manner in
which the mill utilises the thermosol process will depend

on the available equipment, the investment on additional machinery that they can make and the sizes of the dyeing lots in a shade.

While a wide variety of padders can be used, it is desirable to arrange for a long immersion path of the fabric during padding. The dye liquor is preferably kept cold. The number of nips should be atleast 2 but preferably 3. The combination of rubber rollers is preferred to that of rubber-and-steel rollers, the hardness of rubber rollers being 70° to 80° shore. The pad is adjusted to give a pick of about 60%, even squeezing being essential. To avoid cross shading, it is necessary to crown or taper one of the rollers from 0.01" to 0.03" depending on the roller diameter. Predrying immediately following padding is a critical step to ensure good, even dyeing. Dye migration during dyeing will give rise to listing, two-sidedness and generally a poor appearance of the dyed fabric. The drying process is therefore divided into predrying and final drying. The predrier which can be based on IR radiation, heating, convection heating or a combination of the two is placed immediately after, usually vertically above, the nip of the padding mangle. The pre-drier should remove about 50% of the moisture left in the fabric after padding. Pre-driers while not absolutely essential for polyester cotton blend fabrics, do give a better margin of safety in working. In the absence of a predrier, addition of thickners such as sodium alginate or CMC and avoidance of a wetting agent in

the pad bath will also help in controlling migration.
For final drying, a hot flue, heated cans or the air
lay type of drier can be used. Care has to be taken
that at this stage, the temperature on the material
does not exceed $125^°$ to $130^°C$ to avoid premature thermosol
development. For the actual thermo fixation, a stenter
or roller type of oven can be used. The latter has a
higher rate of output but has disadvantages of requiring
a long thread up and the absence of any control over
fabric width. There is also some risk of crease forma-
tion. These disadvantages can be overcome by appropriate
care and the normal resin finishing curing ovens
available in many mills can be used for thermo fixation.
Recently, IR ovens have also been introduced.

Dyes used for dyeing of Polyester cotton blend fabrics
are generally a combination of disperse dyes with any
one of the common class of dye stuffs used for dyeing
cotton, for example, vat, reactive, soluble vat, etc.
The dyeing procedure will consist of two operations, the
first in which the disperse dye is dyed on the polyester
by Thermosol or other suitable process and the second in
which the cotton component is dyed by appropriate
conventional methods used for cotton. Some of the vat
dyes stain polyester and can be permanently fixed on
this fibre under Thermosol conditions. For light
shades it may also be adequate to dye only one of the
component fibres with an appropriate class of dyes. Such
procedure is adopted particularly for soluble vat dyes

beyond acceptable limits. Wool has good strength, elastic recovery and abrasion resistance but has the draw-backs of felting and shrinkage especially in the mildly alkaline soap solutions used for domestic washing. Man-made fibres such as Nylon and polyester have, besides good strength and high elastic recovery, very high abrasion resistance as a result of which fabrics made from these fibres are crush-proof and very durable to wear. On the other hand, these fibres have low moisture regain which leads to discomfort during wear and to problems of dyeability. Table I summarises important properties of the various fibres which are commonly used in blends with cotton.

Recognising the definite advantages and limitations of individual fibres, textile manufacturers and scientists soon realised that multi-fibre textiles afford the maximum scope for obtaining the best advantages of the positive characteristics of fibres and for producing fabrics with an optimum combination of desirable properties. The concept of fibre blends thus came into existence and has been gaining increasing importance in the textile industry ever since. For example, a fabric made from cotton alone would have the disadvantages of easy wrinkling, shrinkage and moderate durability. Likewise, a fabric made from polyester fibre alone would have the disadvantage of discomfort during wear, including development of static charges due to the low moisture regain of the polyester fibres. On the other hand, if one made a fabric from a blend of cotton and polyester, one would achieve the optimum

dyes (which are dyed on cotton) and for disperse dyes which will dye polyester. In either case the second component fibre is left undyed. For the disperse-reactive systems, dyeing can be done by a single thermosol process or by a combination of thermosol and pad steam process. For the single step process, reactive dyes which require only sodium bicarbonate for fixation are preferred since some disperse dyes are sensitive to stronger alkali such as sodium carbonate. In addition to the alkali, the pad liquor consists of urea and an antimigrant, preferably sodium alginate. The single step process, though simple in application and efficient in colour yield, is limited to pale shades and has the disadvantages of limited bath stability, poor chlorine fastness and limited choice of disperse dyes.

Disperse dyes selected for thermosol dyeing must have good fastness to sublimation. Disperse dyes are now available in the form of pastes with excellent dispersion properties. These pastes give non-specky dyeings, are free from dusting, permit preparation of concentrated pad baths and have a finer dye particle size as compared to the powder brand dyes. In the dyeing of cotton-polyester blend fabrics, it is important to control migration of the dye when the padded cloth is dried. Besides pre-drying with infra red heat, migration can also be controlled by addition of suitable thickners and anti-migration agents to the pad bath. Sodium alginate, CMC and sodium polyacry-late are common agents. These thickners' control migration and eliminate the halo effect around neps and slubs.

Some technical problems in dyeing of polyester-cotton blends by the thermosol process are specking, creasing, width control, cross-shading and migration, shade matching, etc. The colour specking problem has been virtually eliminated by the use of pastes of disperse and vat dyes. Likewise, the problem of creasing has been eliminated by improved oven designs. Width control can be achieved satisfactorily if the cloth is framed 1 to 1-½" over the finished width required after passage through the thermosol oven. Cross shading is effectively controlled by use of padders with sufficient crown or taper or by use of a swimming roller pad. Migration of disperse dyes and of formation of halos round neps and slubs is corrected by maintaning adequate concentration of the thickner (anti-migrant) and by careful control of fabric drying. Insufficient IR predrying or very high temperatures on the first phase drying cans lead to migration. For successful matching of shades, the cotton component from the dyed blend is extracted with a 70% solution of sulphuric acid after the shade on the polyester is checked before making adjustments in the dye concentration. Careful control of temperature in the thermosol unit is necessary to minimise problems of shade control especially in cross dyeing.

PRINTING

In general the different dye systems used for dyeing can also be used for printing. Important dye combinations

TABLE VI

Properties of printings obtained with different dyes

	Pigments	Disperse/ Vats	Disperse/ Fibre- Reactives	Modified Vats
Cost	Low	Moderate	Moderate	High
Suitable for shades:				
Light	Yes	Yes	Yes	Yes
Medium	Limited	Yes	Yes	Limited
Heavy	No	Yes	Yes	No
Bright	Yes	Limited	Yes	Yes
Crocking	Fair	Good	Very Good	Good
Effect on Handle	Yes	No	No	No
Ease of application	Very Good	Good	Good	Good

and printing sequences commonly used are outlined in
Table V.

For trouble-free printing the fabric has to be carefully
prepared following the usual routine of desize-scour-
mercerise-heat set-singe-bleach-dry. Desizing must be
complete and uniform and must effectively remove
lubricants. Solvent scouring may be necessary to
remove grease stains. The fabric is preferably free
from rewetting agents. The blend fabric must be
mercerised prior to printing. Heat setting at about
$195^{o}C$ is absolutely essential to avoid the distortion of
the fabric during printing which would make precise
pattern fitting extremely difficult.

It is not possible, due to limitation of space, to go into
details of the printing methods and formulations used
with the different systems given in Table V . However,
a comparison of the properties of printings obtained
with different dyes is summarised in Table VI .

TABLE V

PRINTING SEQUENCES FOR VARIOUS DYE COMBINATIONS.

Resin Bonded pigments	Disperse-pigment	Disperse-Fibre Reactives				Disperse-Vats	Modified Vats	Disperse-Azoics	Disperse-Soluble Vats
Cure	Thermofix	Thermofix	Thermofix	Thermofix	Thermofix	Thermofix	Thermofix	Thermofix	Thermofix
			Pad	Wet develop	Age	Pad	Pad	Age (Neutral or acid)	
			Flash-age			Flash-age	Flash-age		
						Oxidise	Oxidise		
Soap	Soap	Soap	Soap	Soap	Soap	Soap	Soap	Soap	Soap
Finish	Finish	Finish	Finish	Finish	Finish	Finish	Finish	Finish	Finish

Printing Sequences

PROCESSING OF COTTON VISCOSE BLEND FABRICS

Viscose staple is often blended with cotton for reasons of economy or quality. Normally, the proportion of viscose staple in such blends ranges from 15 to 35%. Both being cellulosic fibres with essentially similar characteristics, blending of viscose with cotton does not pose any serious difficulties. The processing methods necessary for the blends are more or less the same as those used for cotton.

It has been observed that yarns spun from cotton-viscose blends have slightly lower (about 10%) breaking strength but better uniformity compared to corresponding cotton yarns. Performance in spinning with blends is usually superior with less ends down. Sizing and weaving also do not present any difficulties or departures from normal practice.

In the chemical processing of the blend fabrics, due attention needs to be paid to the following properties in which viscose differs significantly from cotton:

1. The wet strength of viscose is lower than its dry strength which is contrary to that observed with cotton.

2. Viscose is considerably more extensible in its wet state than in the dry state.

3. Alkali has a powerful swelling action on viscose and

under drastic conditions can dissolve or gell viscose.

4.   The high swelling of viscose in water and its high wet extensibility lead to poor dimensional stability.

Under the normal scouring conditions used for cotton, no significant degradation of the viscose fibre is observed. However, scouring under pressure is not recommended for cotton viscose blends. The temperature of scouring should not exceed $100^{\circ}C$. The alkali concentrations are low (2 to 4%) and temperature of treatment is high, conditions under which swelling and dissolution of viscose is negligible. Inasmuch as the viscose staple fibre does not need such drastic purification as required for cotton, it may be possible to reduce the severity, particularly the duration, of scouring when viscose is blended with cotton.

Mercerising of the cotton-viscose blend fabrics may be undertaken even though the fabric has satisfactory lustre due to the presence of the viscose fibres. Mercerisation would increase the rate of dyeing of the cotton fibre, reduce the difference in dyeing rates between cotton and viscose and thereby help in producing more even and solid shades after dyeing. While the normal mercerisation lye used for cotton can be used for the blend fabrics also, it is absolutely essential to use hot water for washing of the alkali after mercerizing. It may also be necessary to reduce the concentration of caustic soda used for mercerising from about 24% which is normally used for cotton to 18 to 20%. Extra care is required to ensure that the mercerised fabric

4. 2. 74

TABLE 1

TYPICAL TENSILE CHARACTERISTICS OF TEXTILE FIBRES

Fibre	Tensile Strength g/tex	Initial Young's Modulus g/tex	Breaking Extension %	Work of rupture g.cm/tex.	Elastic° recovery %
Cotton	47	750	7	2	35-45
Nylon*	45	200	26	10	100
Polyester* (Terylene)	45	700	30	10	85-90
Viscose*	20	600	20	2½	30-40
Acrylic* (Orlon)	15-18	-	25	-	85-90

* Values are for ordinary Tenacity grade.

● At 5% strain.

combination of the desirable properties of both the fibres, viz. high wrinkle recovery and excellent durability of the polyester and comfort characteristics of the cotton fibre.

The most common blends with cotton are cotton polyester (33:67 and 50:50), cotton-nylon (80:20 to 85:15), cotton viscose (viscose being 10 to 30% approximately), and cotton-acrylic, the last being very occasionally used. In this article, the discussion will be restricted to these fibre blends of which maximum attention will be paid to cotton polyester and cotton-viscose blends which are by far the most commonly used in industry.

Production of multi-fibre textiles can be achieved in two distinct ways: In one method, the yarn is made from a single fibre whereas the fabric is made by using yarns made from different fibres, the warp being of one fibre, and the weft of another. Such fabrics manufactured from single fibre yarns are called union fabrics. The other method of manufacturing multi-fibre fabrics is to blend the required fibres in the requisite proportions and manufacture the yarn itself from the fibre blend. Such blend fabrics gave a better combination of the properties of the individual fibres than is possible in union fabrics. Hence blend fabrics have assumed far greater industrial importance than union fabrics.

Processing of blend fabrics requires extra care because of the presence of more than one type of fibre, with

different reactivities towards dyes and chemicals and therefore involving the risk of non-uniformity in processing quality. Also, the distinctive structure and properties of man-made fibres requires certain modifications in the normal processing technology used for cotton fabrics, the modifications being either in the conditions of the particular process or in additions at certain stages of processing. This article discusses basic processing technology of cotton-polyester blend fabrics together with the important quality control and process control tests and procedures necessary to ensure acceptable quality standards.

IDENTIFICATION AND ANALYSIS OF COMPONENT FIBRES IN A BLEND:

Since blending of the fibres is generally carried out at the draw frame stage, it is necessary to check the long term uniformity of blending. In particular, this is important to ensure the desired shades of dyeing uniformly since the dyeing properties of different kinds of fibres used in the blend may differ significantly. Qualitative and quantitative analysis of the fibres in a blend fabric is also required occasionally by a dyer if he has to match a given sample. Lastly, such an analysis of fibre blends is important for diagnosing the cause of many kinds of dyeing defects.

Qualitative identification of fibres is largely based on the physical and chemical properties of the different fibres. Table II gives a list of various identification

TABLE II
IDENTIFICATION TESTS FOR FIBRES

TESTS	NATURAL			Regenerated Cellulose	Cellulose Derivative		SYNTHETIC	
	COTTON	WOOL	SILK	VISCOSE	ACETATE	POLYAMIDE	POLYESTER	POLYACRYLONITRILE
1	2	3	4	5	6	7	8	9
1) BURNING TEST (EFFECT OF HEAT)	Burns with smell of burnt paper, does not melt.	Burns with smell of burnt feather, some melting	Burns slowly with some melting	Burns with smell of burnt paper, does not melt, decomposes at 350-354°F	Burns with melting, forms black brittle bead, acetic odour, sticks at 350-375°F, Softens at 400°F, melts at 500°F.	Burns slowly with melting, shrinks from flame, forms hard pale brown bead, discolouration at 300°F 445°F, melts at 420°F, decomposes at 500°F.	Shrinks from flame, forms hard round bead, pungent odour, sticks at 445°F, melts at 482°F.	Burns with melting, forms hard black bead odours range from sweet to burnt meat. sticks at 455°F
2) MICROSCOPIC EXAMINATION: LONGITUDINAL :	Flat like a ribbon, convoluted in places	Cylindrical covered with overlapping scales	Smooth, structureless	Striated to smooth	Striated	Smooth or few striations	Rod like with smooth surface	Smooth, twisted or wide striations.
CROSS-SECTION:	Kidney or bean shaped, flat, more rarely elliptical	Round or elliptical, sometimes dark medullated in middle of the cross section	Mostly triangular with rounded corners	Serrated to round	Clover leaf to slightly irregular	Round or trilobal	Round	round, bean shaped, dogbone or lobal
3) SPECIFIC GRAVITY:	1.45-1.60	1.28-1.35	1.20-1.28	1.45-1.30	1.28-1.35	1.10-1.20	1.35-1.45	1.10-1.20

is washed completely free of residual alkali by appropriate washing and neutralising treatments.

In general, processing of cotton viscose blends has to be undertaken with a minimum of tension to avoid undue distortion of the fabric dimensions because of the high extensibility of viscose in the wet state. This problem, thoughmuch less acute than in the case of 100% viscose staple fabrics, does deserve attention to obtain consistently trouble-free processing. These precautions are particularly important when the proportion of viscose in the blend is high, and for processes involving alkali (such as dyeing with vat or azoic dyes). The characteristic wet state properties of viscose also make it obligatory to undertake treatments such as resin finishing for obtaining satisfactory dimensional stability in the finished fabric. In working out the finishing bath formulation, it must be remembered that viscose has about twice as much accessibility as cotton and would therefore require approximately double the concentration of the resin as that used for cotton to achieve comparable dimensional stability and crease recovery. The process control methods used in resin finishing of cotton fabrics must be observed in processing of these blend fabrics also.

The blend fabrics can be dyed with the range of dyestuff types used for cotton. Similarly the dyeing methods for cotton fabrics are suitable for the blend fabrics. In the dyeing of yarn in package form with dyes requiring alkaline conditions, one may have difficulties of uneven and inadequate penetration of the dye liquor through the package because of the considerable swelling of viscose in alkaline solutions. If such difficulties

are experienced the dyeing process can be modified and
those used for viscose staple yarn can be adopted for the
blend yarns.

PROCESSING OF COTTON POLYAMIDE BLENDS

Polyamide fibres are used in various proportions for
blending with cotton. Their high tensile strength and
abrasion resistence give significant improvements in wear
life to the blend fabrics, especially for work clothing.
Polyamide fibres for which the generic term Nylon is
generally accepted, are of two chemical types, Nylon 6 and
Nylon 6.6. The former is derived from caprolactam and has
the chemical structure: $-NH(CH_2)_5CONH(CH_2)_5CO-$.

Nylon 6.6 is manufactured from adipic acid and hexa-
methylene tetramine and has the chemical structure:
$-NH(CH_2)_6NHCO(CH_2)_4CO-$. Nylon 6 has a melting point of
about $215^\circ C$ whereas Nylon 6.6 melts at about $250^\circ C$. The
lower melting point of Nylon 6 is not significant for
most textile purposes though the higher melting point of
Nylon 6.6 is advantageous in certain circumstances.
Nylon 6 has a greater affinity for certain dyestuffs and is
thus more versatile for dyeing. Two-tone dyeings can be
obtained if a fabric constructed from Nylon 6 and Nylon 6.6
is dyed with acid dyes from the same bath. Both Nylon 6 and
Nylon 6.6 are sensitive to ultraviolet light, and yellow
and degrade on prolonged exposure to sunlight. Nylon 6 has
greater resistance to actinic degradation.

Cotton-nylon blends can usually be processed by normal methods used for cotton, with some modifications without risk of degradation. The most significant difference in processing is the need for heat-setting for blends containing more than 30% nylon. Heat-setting can be carried out before or during final finishing and enables a reduction in the residual shrinkage of the blend fabrics in washing and laundering. The heat-setting temperature is controlled to 180° to 200°C. Control of time and temperature are important as in the case of cotton polyester blends discussed in detail earlier.

During scouring of the blend fabric in kiers, addition of about 2% sodium hydrosulfite to the scouring liquor is necessary to prevent discolouration of the polyamide. In bleaching, the usual conditions of peroxide bleaching can be followed. If the polyamide component in the blend is high, bleaching with peracetic acid or sodium chlorite is recommended. Controls of pH, temperature, time and concentration of chemicals are important. The normal mercerising conditions used for cotton are followed and do not adversely affect properties of the blend fabric.

Polyamide cotton blends can be dyed with vat dyes by the pad steam process. Careful selection of dyes is necessary to produce similar depth of shades and hue on both fibres and also satisfactory fastness to light. Since vat dyes vary appreciably in their affinity for polyamide fibres, laboratory matching should be produced before bulk dyeing is carried out.

Reactive dyes can also be applied to cotton-polyamide blends
to produce solid shades. In case differential dyeing of the
two components is required, polyamide can be dyed with
disperse or acid dyes and cotton can be dyed with direct
dyes. Here again, temperature and pH control is very
important and the exact conditions suggested by the
manufacturers should be followed.

Application of resins is mainly for the improvement of
properties of the cotton component. However, any deposition
of resin on the surface of polyamide markedly stiffens the
fabric and produces a harsh handle. This can be avoided by
a thorough after-washing treatment.

PROCESSING OF COTTON-ACRYLIC BLENDS.

Blends of acrylic or modacrylic fibres with cotton usually
contain equal proportions of the two fibres. These blends
are used for the manufacture of suitings, dress-wear,
shirtings and other items of apparel. For speciality
fabrics, higher proportions of acrylic fibres may be used.
The blend fabrics have become popular due to certain physical
properties of acrylic fibres such as low water absorption,
wool-like characteristics and high resistance to most common
chemicals including mineral acids. Most acrylic fibres are
stable to heat below the range of $130^{\circ}- 150^{\circ}C$. However, they
are degraded by hot strong alkalis. This particular property
requires careful attention during the processing of blends.
Conditions of temperature and concentration of alkali are

required to be maintained low during scouring; otherwise entire resilience may be lost. Also any conditions which tend to soften the fibres will affect dimensional stability adversely.

In order to arrive at the most suitable conditions for scouring of acrylic-cotton blends, it is necessary to carry out laboratory experiments. The usual procedure is to take small strips of the fabric and extend them under load in the solution of treatment. The extended fabric strip is allowed to relax in distilled water or soap solution. The fabric should more or less recover completely during the first wet relaxation treatment. In case a certain treatment does not lead to complete relaxation, it becomes necessary to use milder conditions of treatment and use reduced load.
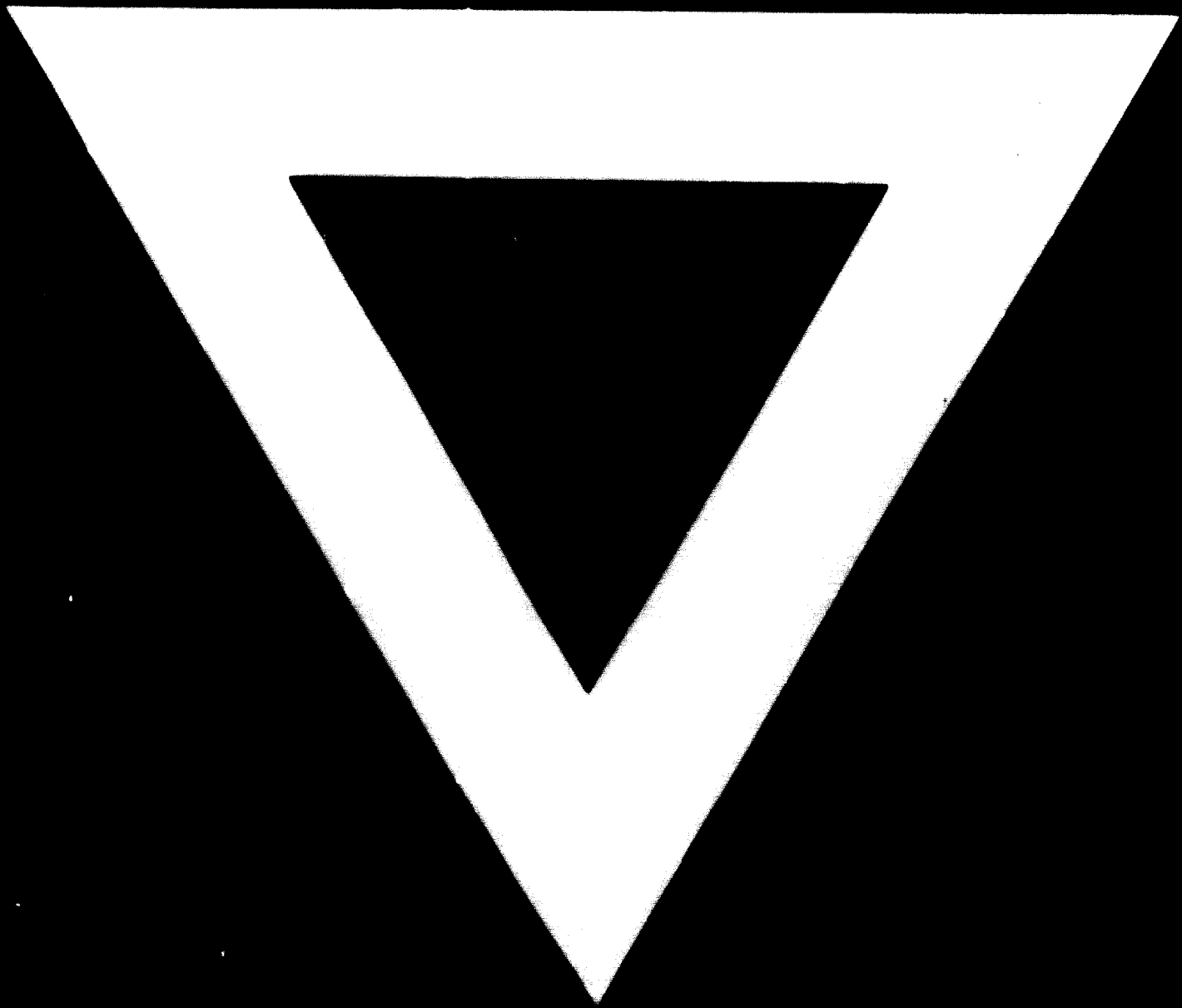
During chemical processing it is also necessary to avoid excessive stretching of the blend fabric. In general, the pressure and temperature conditions of the finishing operation and stretch should be controlled to avoid glazing and discolouration of the acrylic fibre. Particularly when fabrics are resin treated the acrylic fibre tends to discolour during polymerisation. Drying temperatures during processing should be as low as practicable if soft handle is required.

Satisfactory bleaching results are obtained with sodium chlorite. In order to avoid variation of damage to either component, control of temperature, time of treatment and

concentration of oxidising agent is necessary as in bleaching of other materials.

Fabrics intended for dress-wear are usually dyed by application of disperse or basic dyes for the acrylic fibre and direct, reactive or vat dyes for the cellulosic fibre. Here also, temperature of treatment plays an important role. The padding temperature with either basic or disperse dye should be around 70°C and steaming temperature should not exceed that suggested by the manufactures of the acrylic fibre. Control of exact temperature in dyeing methods is of very critical importance. Even small changes in temperature around 80°C produce a large change in the dye uptake of the acrylic fibres. When basic dyes are used, it is advisable to control the pH of the dye bath at around 5. In order to maintain brightness of shade, cotton is usually dyed after the dyeing of acrylic component. In case the cellulosic fibre is dyed first, it is necessary later on to give a reduction clearing treatment.

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