

What is dyeing?

→ process of adding colours to textile products

- fiber
- yarn
- fabrics

→ in sol. solution

- dyes
- chemical material

→ After dyeing, dye molecules $\xrightarrow[\text{chemical bond}]{\text{uncut}}$ fiber molecules

⊛ Two factors

- Temperature
- Time controlling

Two types of dye

Natural

Man made

In history, primary dye source from nature

- animal
- plant

Mid 19th century → artificial dyes introduced

- achieve more colours
 - make dyes more stable
- resist washing & general use.

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Diff classes of dyes $\xrightarrow{\text{for}}$ diff types of fiber
diff stages of textile $\downarrow$
production process.

$\rightarrow$ From loose fibers to yarn &
cloth to complete garments.

There are types of dyes.

- ① basic dyes [Acrylic fibers]
- ② acid dyes [nylon & protein fibers - wool & silk]
- ③ disperse dyes [polyester yarn]
- ④ vat dyes
- ⑤ reactive dyes } Cotton.
- ⑥ direct

Natural dyeing:

derived from plants,
^{no back bone animal}
invertebrates or minerals.

Purple - snail
brown - octopus
invertebrate
- snails, fly,
spider

$\rightarrow$ major source - vegetable dye.

from plant sources - roots, berries, bark,
leaves & wood.

Other sources - fungi & lichens

Yellow from
cow urine
Red & Red violet
lac insect

Plants - yellow - pomegranate peel, wild herb - yellow, yellow, green & blue
- myrobolant (ശബരി)

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(Fungi)

Fungi → mushrooms.

Lichens → பரணியாமினல் தாவரம்
தாவர தாவரம்

→ dyes obtained from F&L → Mycopigments.

→ found in flesh of F&L

→ some wild mushrooms

- permanent dyeing

- protein fibers (wool, silk)

→ not from all types but certain dye mushrooms

In China, more than 5000 yrs back traced

ND

→ Many natural dyes → chemicals → Mordants

Mordants:

Fix dye to textile fibres.

Mordants like

- Tannin (extra things from plant)

- Salt

- natural alum

- Vinegar

Ancient dye stuffs:

- Locally available materials. (mostly)

- Scarcely brilliant & bright

permanent colors. [Tyrian purple]

- highly priced luxury items.

Man made / artificial: 9

- synthetic dyes (according to chemical composition)
- ~~mainly from petroleum.~~

According to solubility dyes classified:

Acid dyes: water soluble dyes.
silk, wool, nylon (protein fibers)
vinegar (acetic acid) or citric acid

Basic dyes:

- water soluble → c. ther.
(acrylic fibers) [synthetic fibres]
- Mordant used

Direct dyes: boiling point soluble,
heated & dyed.

Mordant dyes: needs mordant

- improves fastness of dye

Vat dyes: insoluble in water

- incapable direct dyeing.

- reducing agent needed

[caustic soda, sodium

hydro sulphite]

- only soluble when its reduced form.

(indigo example)

Reactive dyes: water soluble dye

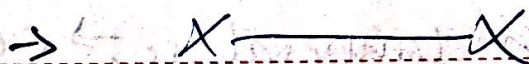
- needs chromophore [a molecule responsible for its colour]
- This helps to react directly to fiber of fabric.

Disperse dyes:

also water insoluble dyes

[polyester & acetate fibers].

- based on azobenzene



Basic dyes:

- with mordants [cotton, linen, acetate, nylon] can be dyed.

→ other than aniline, it is not suitable for other fibers.

→ bcoz not fast to light, washing / perspiration

Direct dyes:

→ cellulose fibers.

→ directly on fabric without mordant.

wool, silk, nylon, cotton, rayon etc.

→ not very bright

→ poor fastness to washing but fair to light



so called
hook → • non soluble • molecularly dispersed. 11
• ∴ dispersing agent necessary → for coloration with disperse dyes.

Disperse dyes:

→ water insoluble.

→ finely ground
in paste / powder (gets dispersed in water)

→ dissolve in fibers & fix colour to them.

→ usually for acetate but now nylon, acrylic fibers too.

→ applied in aird condition

→ in high temperature → economical

Sulphur dyes:

→ insoluble.

→ Made soluble by
• caustic soda
• Sodium sulfide.

→ dyeing at high temperature.

• large quantities of salt used.

• so colour penetrates into fiber.

→ After dyeing,

• fabric oxidized.

• for desired shades.

• by exposure to air / chemicals.



→ Excess chemicals & dyes

• removed ~~using~~ by washing.

→ Fast to light, washing & perspiration.

→ Cotton & linen.

Pigment dyes:

→ not actually dyes.

→ used for colouring cotton, wool & other man made fibers.

• excellent light fastness (due to)

→ Don't attach to fibers but to fabrics.

• with help of resins. (Gum)

→ After dyeing, fabric subjected to high temperature.

→ So that gum like resin helps to fix colour.

Mordant dyes:

→ acidic in nature

cotton,
linen, silk,
rayon & nylon.

→ sodium/potassium bichromate

• used in dye bath. (or)

• after dyeing process completed (dip it)

[but less effective for them]

→ This done for binding action of dye

→ Mostly for wool

• gets good colour fastness

• after treatment with mordant dyes.

Vat dyes:

- insoluble in water
- cannot dye directly
- by reduction in alkaline solution help to affix (stick)
- subsequent oxidation / exposure to air restore to insoluble form.
- Indigo original vat dye.
- Fastest dye for cotton, linen & Rayon.
- For dyeing other fabrics
 - wool, nylon, polyesters, acrylics & modacrylics.
- Mordants used.
- Some times causes skin diseases

Reactive dyes:

- React with fiber molecules to form chemical compound
- Heat treatment
 - for developing diff shades.
- After dyeing, fabric washed with soap.
 - remove unfixed / excess dye.

→ originally for cellulose fibers (cotton, linen)
but now wool, silk, nylon,
acrylics & blends.

Objectives of dyeing:

→ Colour the textile substrates [Fibers, yarns, fabrics, garments] uniformly & producing uniform levelling.

→ Achieve acceptable durability of colour

- to further treatments in production
- normal end use

→ Reproducing required shade.

- from batch to batch.

→ Using reasonably priced dyes & dyeing procedure.

→ Operating according to ecological requirements.

- carrying out in short time.

⇒ Dyes used in colouring textile fiber are synthetic compounds.

→ To serve as a useful dye it should have following features.

- Intense colour. (Strength of colour (How colour impart to textile))
- Solubility in water

(During process of dyeing, dyes should be soluble in water, so that water can carry dyes to inner molecular structure of the fibre.)

- Substantivity to the fiber.

(How dye molecule penetrate inner molecular structure of the fiber).

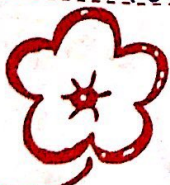
- Durability to wet treatments.

(Once dye penetrated to inner molecular structure, chemical bond takes place b/w fiber & dye molecules).

→ Colour fastness properties of dye.
→ if increased fastness → durability to

further treatments.

ex. washing.



→ Safe, easy to handle & reasonably priced.

3 ways of imparting colours to textiles:

Method 1: Aqueous / conventional dyeing

Method 2: pigments

Method 3: solution dyeing.

M-1: → Most (X) & most widely used method.

→ process involves use of dye stuffs.

→ treatment of textile material in aqueous (water) solutions.

M-2: → pigments are microscopic sized insoluble coloured particles.

→ Applied on textiles using special treatments.

M-3: → It is part of manufactured fiber production.

→ involves adding micro-sized coloured pigment to man-made fiber during manufacture.

→ The pigment is added while the fiber is in

- liquid / solution form. e
- before extrusion from a spinnerette.

Important terms:

Affinity - to define attraction b/w dye & fibers.

Ex: direct dyes - strong affinity for cotton.
means
direct dyes have very high attraction for cotton.

Substantivity: Technically, affinity & substantivity mean same.

The dye which have high attraction produces dark shade.

• called highly substantive on fiber.



Dye bath:

→ all amnt of dyes

- dyeing assistants (chemicals, mordants)
- liquor ratio (water)

measure & recorded accurately.

→ To follow precisely in future runs.

→ All dyeing assistants in any dye bath should be used only if necessary.

→ Using excessive amnts (larger than recommended) of any additive should be avoided.

MATERIAL TO LIQUOR RATIO:

To ensure uniformity throughout dyeing bath

- a small solution
 - dispersion of dye
- } made first:

→ Extreme care must be practiced in preparation of these solutions.



→ un-dissolved dye particles,

Cause:

• un-level dyeing

(or)

• form ^{microfibrils} specks on the goods.

→ The dye solution is filtered through

• filter before entering system.

→ Also, when preparing concentrated solutions

• dyes & dyeing assistants

• should not be mixed together.

→ in concentrated form.

→ unless specifically required.

→ This ratio indicates

• how much liquor (water) to be taken

• for dyeing given weight of mtl.

→ The total quantity of water to be taken
for dyeing

↓ depends

upon weight of material to be dyed.

Expressed in terms of M:L ratio.



Thus, a material: liquor ratio of 1:20 means weight of liquor should be 20 times the wt. of material to be dyed (fabric)

Percentage of shade:

→ based on weight of material taken for dyeing

Thus, when a 2% shade to be produced on cloth.

2gm dy for 100gm cloth for dyeing.

does not mean cloth contains 2gm dy / 100gm cloth after dyeing.

WASH CYCLES:

→ removes un-bonded dyes

→ dyeing assistants
from fibres.



→ Procedure varies from

- mild rinse with warm water to
- use of detergent solution

→ Bleeding of dye from new cloth in 1st laundering

↓ result of
poor rinsing

↓ in

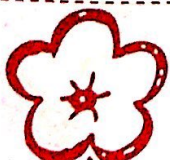
final stage of dyeing process.

COLOUR FASTNESS:

→ Durability :-

→ of colours against various forces like

- washing
- Rubbing
- sunlight etc.



applied in bath contains mineral/organic acids like Sulphuric, acetic/formic acid. 22

Acid dyes: properties

→ Acid used in dye bath

Vinegar (acetic acid) or citric acid.

→ uptake rate controlled with use of sodium chloride.

→ effective on protein fibers

• i.e. animal hair fibers

ex: wool, alpaca & mohair.

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also → effective on silk.

effective in dyeing synthetic fiber nylon

properties:

→ soluble in water.

→ These dyes generally supplied in presence of acids like

- Sulphuric
- acetic
- formic acids.

→ When acid dye stuffs are treated with

- Reducing agent.
- generally decolourizes.

→ usually combine with basic dyes.

→ good light fastness & moderate washing fastness.

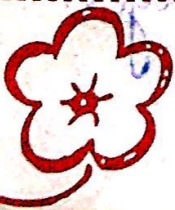


Basic dyes:

- They are salts of organic bases.
- also called cationic dyes.
- wool, silk & acrylic & modacrylic fibres.

Properties

- outstanding characteristics
 - Brilliance
 - Intensity of their colours.
- bright colours achieved do not occur in other dye classes.
- many basic dyes soluble in water.
- addition of glacial acetic acid
 - helps basic dye dissolve quickly.
- Poor fastness to light.
- vary with regard to washing fastness from poor to moderate.
- by back tanning,
 - treating dyed material with tannic acid
 - settles the w. to improve wet fastness properties



24. → Dyeing process with direct dye simple.
 Direct dyes: → cotton, leather, wool, silk & nylon.
 → carried out in neutral dye bath.
 → also called substantive dye.

properties → water soluble compounds

, affinity for fibres.

→ usually cheap & easily applied

→ yield bright colours.

→ poor wash fastness.

→ Various after treatments use to improve wash fastness.

→ adhere to fabric molecules
 • without help from other chemicals.

A B D D M P R S V

Solubility

→ Soluble → A, B, Dis, M, P, R, V

→ Insoluble → Dis, S, V

Fastness

→ Light fastness

→ Poor → B, Dis

→ Good → A, good Dis, P, R

→ Wash fastness

→ Poor → Dis

→ Good → Dis, R

→ Colour fastness → good by mordant

→ average → Sulphur

Colour → bright → B, Dis,

→ low → A, Dis,

Cotton - Direct, Sulphur,

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Silk - Basic, Direct, ~~vat~~, Reactive

Wool - Acid, Basic, Direct, Vat, Reactive

Nylon - Vat, Reactive.

Fastness properties of dyes.

Colour fastness:

→ is a term:

- used in textile dyeing materials
- characterizes a material's colour

→ resistance

↙ to ↘

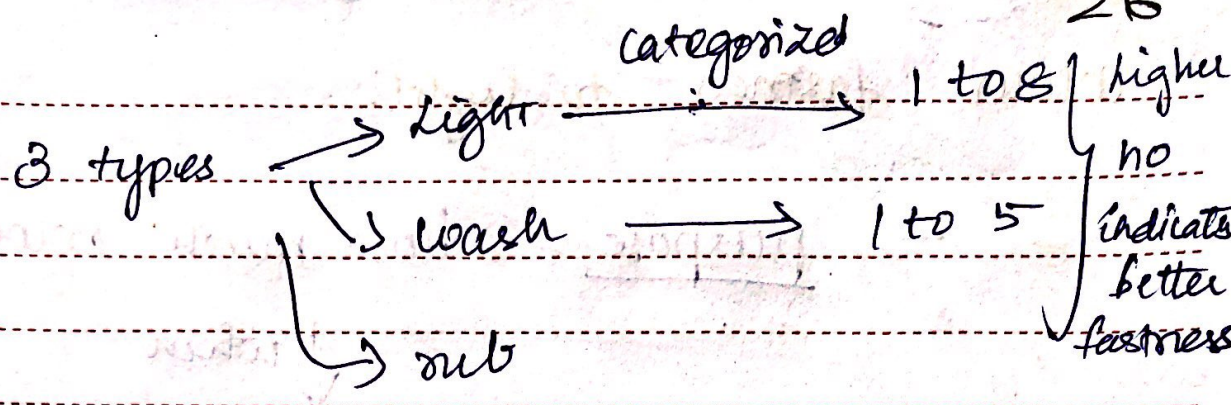
- fading (or) running

→ clothing should be tested → LF

↓ before

bleach / cleaning products.





→ one of (X) factor in buyers demand.

→ (X) property of dyed material

↳ fastness of shade of colour.

→ refers to → resistance of color
 ↓ to
 fade / bleed

↓ of
dyed / printed textile

↓ by

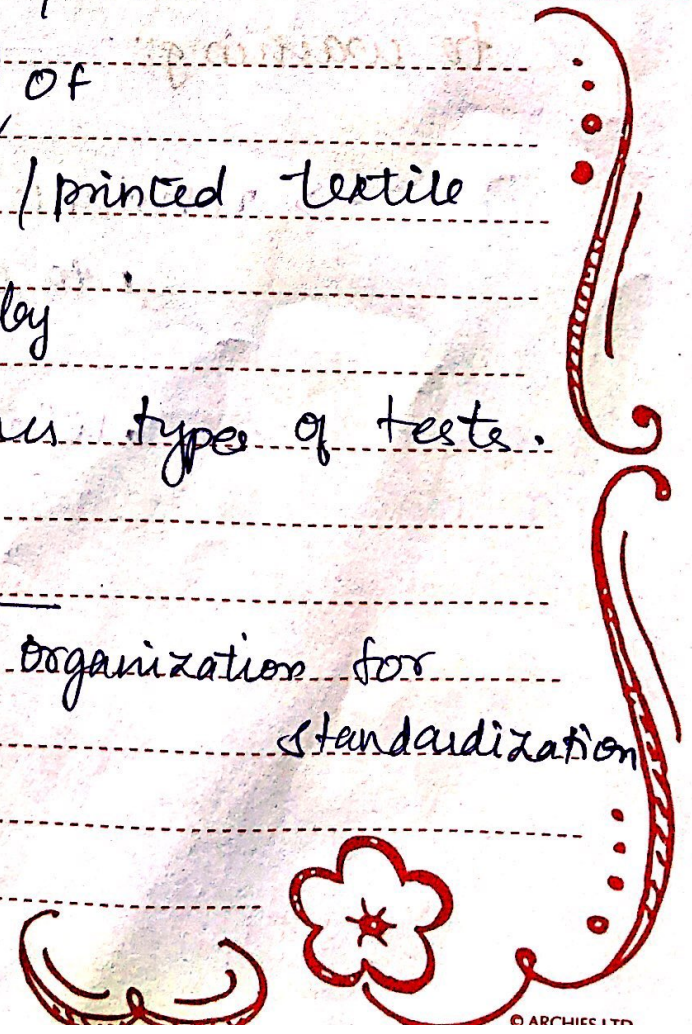
various types of tests.

Standards for fastness

ISO - International organization for standardization

→ for light — 1-8

→ other — 1-5



colour fastness to light:

→ purpose → how much colour fades

↓ when

exposed to known light source

Ex: man wears fabric

goes out for job

→ in day → sunlight fall on fabric.

→ so how much protection ability have a fabric to sunlight

to washing:

→ resistance of a material

• to change in any of its

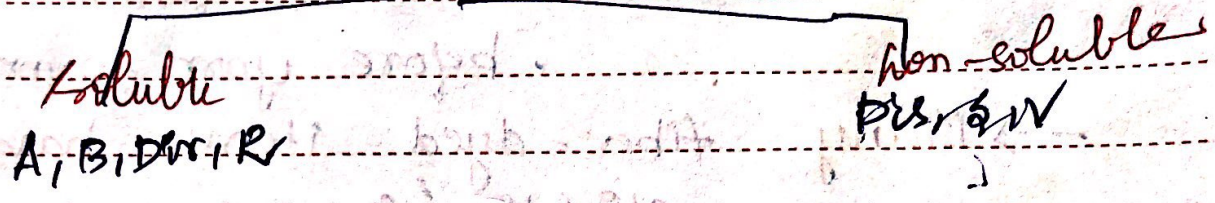
color characteristics

• when subjected to washings



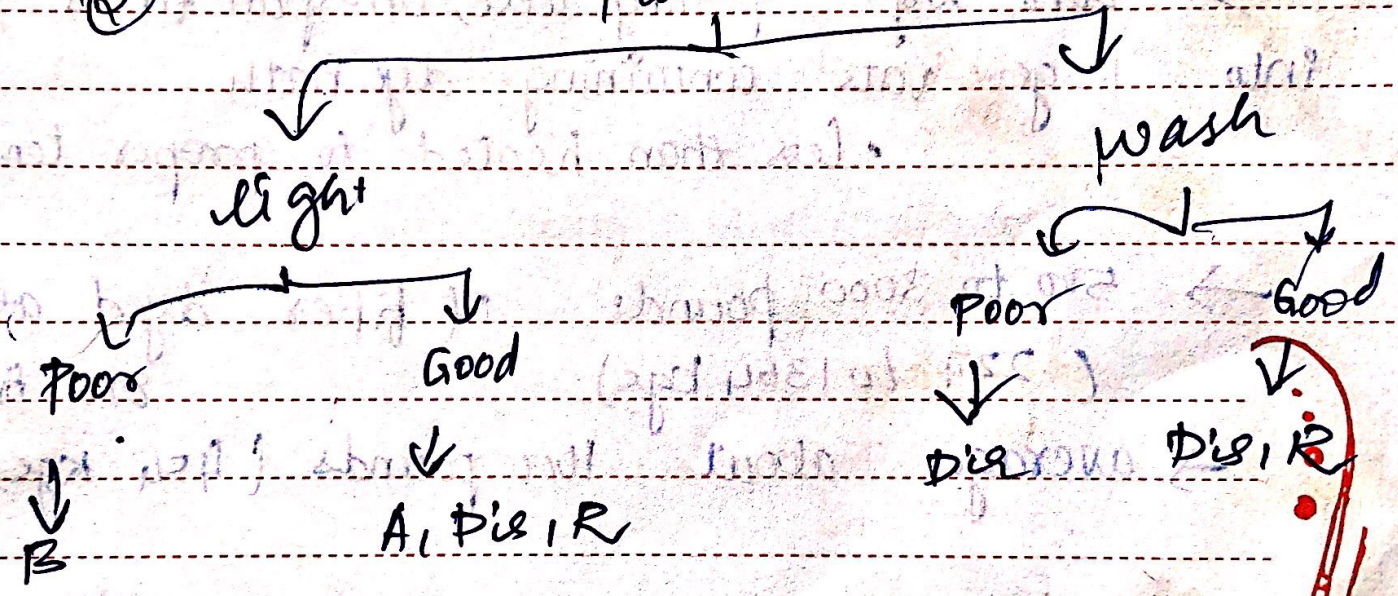
①

Solubility



②

Fastness



③

Coloring
 Bright - B
 Faded - A, D, R

④

Cotton - Dis
 Wool - A, B, D, V, R
 Silk - B, D, R
 Nylon - R, Dis



- In fiber dyeing process,
 - colour added to fibers
 - before yarn spinning.
- Many fiber-dyed items have
 - slightly irregular colour.
 - Ex: heather / tone-on-tone gray.
- Done by putting loose, un-spun fibers into large vats containing dye bath
 - less than heated to proper temp.
- 500 to 3000 pounds of fiber dyed at one time.
 - (227 to 1364 kgs)
- average about 1000 pounds (454 kgs)

Advantages:

- fabrics have soft, heather like colouration
- Earliest dye penetration.

Disadvantages:

- costly method.
- Dyeing long before season begins
 - carries risk of fashion changing.
- high % of fiber loss from dyeing & later yarn spinning.

Typical dyed fibres:

→ chenille → Melton
→ covert → Tweed.

Methods:

1. old:

→ removing packed fiber from bales

↓
packing stock in large vats.

↓
circulating dye liquor

through mass of fiber

at

elevated temperatures.

2) New:

Bale Dyeing

↓
applicable to wool & all man-made fibers

→ splitting bale covering all 6 sides

↓
placing entire bale in machine along with
covering & straps.

↓
forcing dye liquor through bale

saves time & costs.

→ overall even colour obtained. 31

→ stock dyed fiber doesn't spin as readily as undyed fiber.

→ loses some of its flexibility.

→ lubricants added in final rinsing.
• overcome most of this problem.

woolens:

often stock dyed.

uses:

→ Oxford suitings.

→ Tweed home spins

→ Heather effect materials in which
• delicate shadings of colours.

↓ produced by

combining fibers of various colours

Machinery & technique:

Types:

• Conical pen machine

• pear shape machine

• Radial flow



~~Conical~~

various types of machines

✓
10001

synthetic fibers } in loose form.

→ types:

→ loose fibre typically packed into these machines manually.

Conical pan machines:

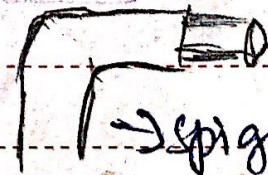
→ fiber packed in removable fiber carriers.

fiber carriers:

→ located on central spigot

↓ in

base of vessel.



→ spigot

→ liquor circulation by external pump.

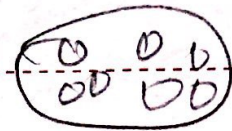
→ pipe work allows

→ liquor to be circulated

• either from base/top.

pear shape machines:

33



→ removable ^{rows of small holes} perforated bar plate

↓ through which

liquor circulated ↓ via

(liquids from solids)

an impeller → rotating

rapidly rotating container

part of

→ fiber loaded directly.

← Centrifugal pump

- a perforated plate positioned

on top.

→ liquor circulation packs fibre b/w

2 plates.

→ unloading: plates removed by cranes & fibre manually

Radial flow:

→ fiber carrier equipped with central perforated column.

→ column: liquor flows along the pack to walls of the carrier.



PROCESS:

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Preparations:

→ Dye stuffs dissolved in hot water & added to circulating dye bath

→ Typical dye stuffs & chemicals for the fibre are employed:

→ In majority cases

- all chemicals & dye stuff solution made

to open dyeing ← manually machine

→ for synthetic fibres,

- less frequently
- pressure dyeing machine utilised

pre-dissolved chemicals & dye are

introduced to

special addition tanks → circulating dye bath

Time:

→ run for 10-15 mins.

→ ensures even penetration of liquor

through

fiber pack

therefore

heating cycle



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→ raise dye liquor temp to 98°C at rate of $1-2^{\circ}\text{C}/\text{min}$.

→ on reaching top temp, dyeing continues up to 60 mins.

• → @ this stage dye bath pH checked.

• → adjusted by adding acetic acid

favourable pH 10.5-11.5

↓ to achieve

maintain correct pH → sodium carbonate add. → defines acidity & alkaline nature

→ power of hydrogen progresses of dyeing checked.

→ by eye.

→ fiber samples then removed

↓ for comparison

with a standard.

Termination process:

→ dyeing which is judged to be on shade

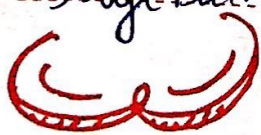
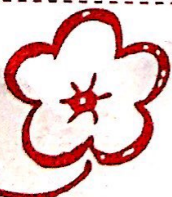
↓ will be terminated & machine drained.

for not achieving required colours:

→ addition of one/more dyestuffs.

→ dye bath being returned to boil.

(repeated) after each addition.



→ Because of blending operation,

• which follows loose fiber dyeing

• it is uncommon for there

↓ to be

more than 1 shade addition.

↓ unless

machine load is only fibre in batch.

Removing undyed - stuff:

→ Dyeing followed by rinsing with cold water,

↓ to remove

→ any surface-bound dyestuff

→ to cool the dyepack before manual unloading.

Draining process:

→ The machine may be filled with cold-water ↓

• run for 10-15 mins before draining.

Flood rinsing process:

→ In this, dye bath is allowed to spill

↓ & then

run continuously to drain

↓ during rinsing operation.

→ now much less common due to increases in

water charges & effluent disposal costs.

liquid waste/sewage discharged into river/sea.

Recycling process:

→ Liquor from both $\begin{cases} \rightarrow \text{dyeing} \\ \rightarrow \text{rinsing} \end{cases}$ recycled for further use

→ In this case, machine fitted with an external holding tank.

Dye bath:

→ may be recycled $\xrightarrow{\text{if}}$ no. of dyeings

bigger dye lot $\xrightarrow{\text{to make up}}$ performed $\xrightarrow{\text{are being}}$ same shade $\xrightarrow{\text{of}}$

→ Dye bath $\xrightarrow[\text{to}]{\text{Pumped}}$ reserve tank $\xrightarrow{\text{dropped back to}}$ dyeing vessel $\xrightarrow[\text{when required}]{\text{for next dyeing}}$

Limitations:

→ Starting at too high temperature

↓ result in an unacceptable & uneven application.

→ Dye stuffs & dyeing conditions must provide maximum uptake of dye.



Alternatives:

→ more usual to recycle rinse liquor.

- Temp lower
- more compatible with dyeing start temp.

→ Depending on design of machine,

→ reserve tank may not be required.

→ fiber carrier can often be removed

↓ with

dyeing vessel full.

→ These conserve water & thermal energy of lesser degree.

