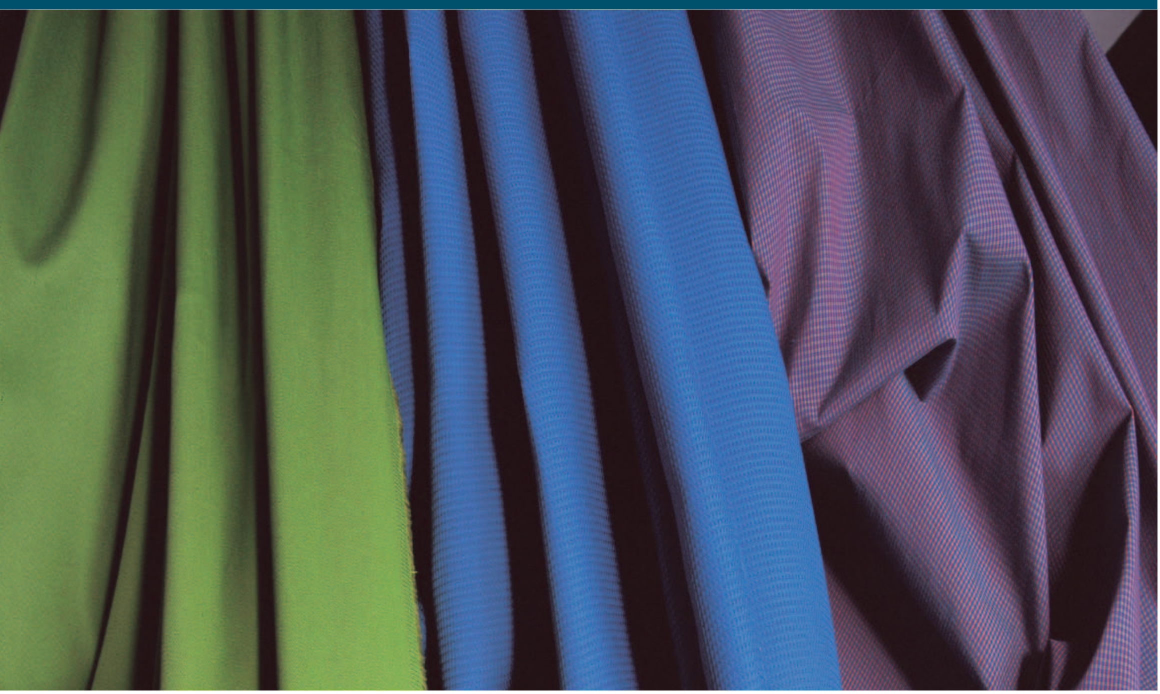
Alternative Production and Cost Savings in Winch-Dyeing



Alternative Production and Cost Savings in Winch Dyeing

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The work has been undertaken by the Stockholm Environment Institute, the Bangladesh Centre for Advanced Studies and the University of Leeds.

More information about the project, including downloads of project documents, can be found at http://www.sei.se.

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1.1 Improved Fixation

Fixation levels for reactive dyes, when doing deep dyeings, can be as high as 70%. Tests in several factories in Bangladesh, have shown that currently fixation ranges from 40-65%, some 5-30% below the possible maximum.

If, on average, the fixation is 50% then about 20% of the dye is essentially being wasted. If 20 kg of dye is used to dye a batch of 200 kg of fabric then 4 kg is being wasted per batch. If, on average, dye costs Tk. 260 per kg then this is a loss of Tk. 1,040 per batch.

If a factory dyes 1,000 tonnes of fabric each year, using 100,000 kg of dye and wastes 20% because of poor fixation, this is the equivalent of a loss of Tk. 5,200,000 per year (approximately US$ 81,595) (Table 1).

Table 1: Explanation of the Calculations of the Cost of Wasted Dye per Year

Explanation	Average
Fixation loss (%)	20
Fabric processed (kg)	1,000,000
Total dye used (kg) (in ratio 1:10 with fabric)	100,000
Dye wasted (kg) Total quantity of dye used per year x percentage of dye wasted	20,000
Cost of dye (Tk per kg) Average value for dye costs according to supplier's manual	260
Cost of dye wasted (Tk) Cost of dye x quantity wasted	**5,200,000**
Approx cost per year (US$)	**81,595**

Exercise 1

Fill in the spaces below with figures for your factory to estimate how much money spent on purchasing reactive dyes you would save by optimising dyeing:

a. Fabric dyed per year (kg) ....

b. Quantity of dye used per year (kg) ....

c. Average fixation achieved* (range of 40%-70%) ....

d. Avoidable percentage of dye lost (70% - c) ....

e. Quantity of dye lost per year (kg) (b x d) ....

f. Average price of dye (per kg) bought by factory (Tk) ....

g. Annual cost of buying dyes (Tk) (b x f) ....

h. Cost of 'avoidable' dye lost per year (Tk) (e x f) ....

The 'avoidable' cost of dye wasted each year (h) is the potential cost saving from using less dye as a consequence of improving fixation.

** Fixation levels can be calculated based on the absorption of visible light by dyes in solution, in dyebaths and in wash baths, using a spectrophotometre.*

1.2 Right First Time

Further savings can be made by ensuring that the recipe is carefully developed to suit the dye type being used (see Chapter 2) and that the recipe is accurately followed on the factory floor. Research in factories in Bangladesh suggests that errors due to incorrect recipes or not following the recipe could result in around 20% of fabric being re-shaded and around 10% being re-bleached and re-dyed. If this is the case then it is possible to make yet more savings by improving the number of “right first time” dyeings.

For example, based on actual dyeing costs provided by factories in Bangladesh, if a factory dyes 1,000,000 kg of fabric per year, and has to re-shade 20% and re-dye 10% because it did not get the shade “right fist time”, the factory is incurring US$ 90,946 per year of unnecessary cost*. This loss is made up of the cost of using more chemicals, dyes, energy for operating equipment and labour (see explanation of costs, Table 2).

The factory can also lose money because time spent for re-dyeing or re-shading is time lost from meeting other orders. In extreme cases business can be lost altogether due to customer dissatisfaction with the time taken to produce goods.

Table 2: Explanation of Annual Cost of Re-shading and Re-dyeing

Explanation	Average
Re-shading (%)	20
Re-dyeing (%)	10
Total production per year (kg)	1,000,000
Costs of re-shading per year (Tk) Cost of 20% extra chemicals, dyes, energy and labour	966,000*
Cost of re-dyeing per year (Tk) 10% of total cost of production each year including chemicals, dyes, energy and labour	4,830,000*
Cost per year (Tk)	**5,796,000**
Cost per year (US $)	**90,946**

** These figures are based on actual dyeing costs provided by factories in Bangladesh. Any factory calculating their own potential losses from re-dyeing must first determine their operating costs.*

Exercise 2

Estimate how much your company could save if it did not have to re-shade or re-dye. Fill in the blanks with figures for your company:

a. Fabric dyed per year (kg)..

b. Cost of dye per kg of fabric dyed (Tk) ....

c. Cost of other chemicals per kg of fabric dyed (Tk).........................

d. Cost of labour per kg of fabric dyed (Tk) ....

e. Cost of energy per kg of fabric dyed (Tk) ....

f. Total cost per kg of fabric dyed (b+c+d+e) ....

g. Estimated quantity of production re-dyed per year (kg) ....

h. Estimated quantity of production re-shaded per year (kg) ....

i. Estimated cost of re-dyeing assuming it is 100% of the total production cost* (f x g)...

j. Estimated cost of re-shading assuming it is 10% of the total production cost* (10/100 x f) x h...

k. Total cost (i+j)..

The cost (k) is equivalent to the potential cost saving from achieving "right first time" every time.

** These percentages are only estimates and for a more accurate result each factory should calculate the actual cost of re-shading and re-dyeing based on the costs in b-f. For example, re-shading may take an extra 30 mins at 60°C, using 5% of the total energy used in a dye cycle.*

2

Reactive Dyes

Reactive Dyes

Reactive dyes receive their name because they contain reactive groups that can react with the fibre being dyed to produce a permanent chemical bond between the dye and the fibre.

There are many different reactive systems, but the two major reactive groups, which give their name to the dye type, are “monochlorotriazine” (MCT) dyes and “vinyl sulphone” (VS) dyes. These dyes “react” in different ways and they require different dyeing conditions, particularly in terms of pH, and temperature and time profiles.

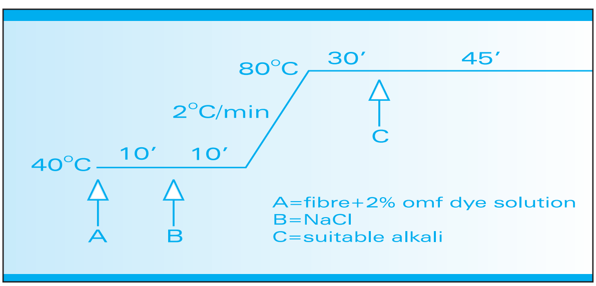
Dyes can contain more than one of these reactive groups. If they contain two of the same group they are called “homo bifunctional” reactive dyes (e.g. MCT-MCT or VS-VS). With these, each dye molecule provides twice as many chances for the dye to react with the fibre. If a reactive dye contains a mixture of two reactive groups it is called a “mixed bifunctional” or a “hetero bifunctional” dye (e.g. MCT-VS). Hetero bifunctional dyes can normally react under a wider range of dyeing conditions.

Reactive dyes must be used under the correct conditions to ensure high fixation levels and better “right first time” dyeing.

2.1 Monochlorotriazine Dyes

Typical dyeing conditions:

- Dye at 80°C
- In the presence of an electrolyte (e.g. NaCl)
- pH 10.5 after addition of a suitable alkali
- Dye for 30-60 mins after the addition of alkali depending on the depth of fabric shade

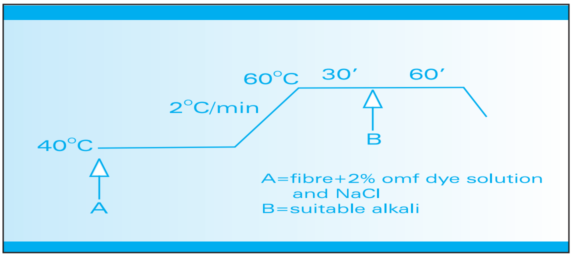


Example: Procion Red H-3B, C.I. Reactive Red 3

2.2 Vinyl Sulphone Dye

Typical dyeing conditions:

- Dye at 60°C
- In the presence of an electrolyte (e.g. NaCl)
- pH 11.5 after addition of suitable alkali
- Dye for 30-60 mins after the addition of alkali depending on the depth of shade

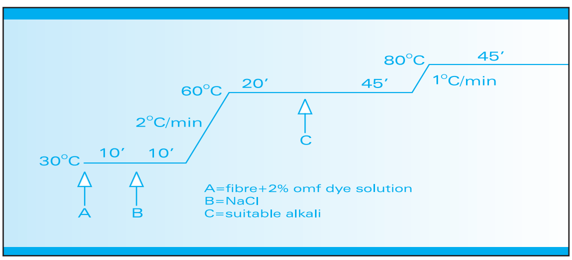


Example: Reactron Black B, C.I Reactive Black 5

2.3 Mixed Bifunctional Dyes: Vinyl Sulphone and Monochlorotriazine

Typical dyeing conditions:

- Dye at 60°C and raise to 80°C to ensure both reactive groups are used
- In the presence of an electrolyte (e.g. NaCl)
- pH 11.5 after addition of suitable alkali
- Dye for 30-45 mins at 60°C after the addition of alkali and then ramp to 80°C and hold for 30-60 mins depending on the depth of shade



Example: Reactron Black HFGR

The commercial names of many dyes provide information on which reactive group they contain.

3

Optimal Recipes and Laboratory Practice

Optimal Recipes and Laboratory Practice

The laboratory plays a crucial role in the development of optimal recipes. A key condition is that the dye types discussed in Chapter 2 should not be mixed when creating dyeing recipes. Only compatible dyes should be used, for example, MCT with MCT, VS with VS, or MCT-VS with MCT-VS but never MCT with VS. Using the same dye type in a recipe ensures that the correct dyeing conditions can be used for all dyes so that the maximum quantity of dye possible reacts with the fibre, giving maximum exhaustion and fixation.

The dyeing time-temperature profile is very important and should be based on the dyes used. It should be clearly documented for each recipe developed, and the recipes and procedures carried out in the laboratory should be properly followed on the factory floor.

3.1 Laboratory to Bulk

There will be differences between factors in the laboratory and on the factory floor for example: agitation of fabric and machine efficiency. There are also differences in procedures such as: the number and type of auxiliaries added; the number of wash-offs; and the vigour of washing. These differences may mean that the shade attained in the lab is different to that on the factory floor, for example more vigorous washes can lighten the shade. When differences occur the recipe is usually altered in some way, such as a dye addition, to give the correct shade. If this is done, all changes must be recorded and documented properly to reduce the need to repeat them. For example if it is regularly observed that a 10% shade addition is required when going from lab to bulk, then this can be added to the recipe from the start. This should improve the frequency of “right first time” dyeing.

These variations between the lab and the factory floor mean that there needs to be strong communication between laboratory staff and staff on the factory floor. Lab Managers and Dye House Floor Managers need to establish a good relationship and work together towards following the optimal recipes created in the laboratory and reproducing them on the factory floor. Careful observation and monitoring need to take place to ensure that the correct shade is produced, and any variables are considered and compensated for during the transfer from laboratory to bulk dyeing.

3.2 Equipment

Good equipment in the laboratory that best represents the machines on the factory floor greatly improves the frequency of “right first time” dyeing. Additional equipment can be purchased to monitor dyeing efficiency, but in general a good understanding of dye chemistry and good shade matching equipment is likely to be sufficient.

On the factory floor, machines that are automated will improve the dyeing process by maintaining the correct time, temperature and pH.

4

Housekeeping

Housekeeping

Good housekeeping is a no or low cost way of improving efficiency and reducing costs.

4.1 Storage

Containers must be tightly shut and kept dry so that the dyes do not absorb moisture. Dyes and auxillaries that are sent in plastic bags, inside cardboard boxes should be transferred to airtight drums.

Uptake of moisture makes reactive dyes and auxiliaries heavier and therefore an incorrect quantity of dye or auxiliaries can be measured out. In the case of dyes, this will reduce the effective depth of dyeing and result in the need for re-shading. Moisture can also accelerate the hydrolysis of reactive dyes, (when the dye reacts with hydrogen ions in the air) especially in warm conditions, which will also contribute to lower fixation because the dye becomes less reactive.

Logbooks should be used to record when dyes come into the store and should be updated when dyes are used or replaced. A sample of every new shipment of dye must be sent to the laboratory and tested before being used on the factory floor as each shipment may be slightly different.

4.2 Handling of Chemicals

The dyes and chemicals must be accurately weighed using appropriate scales to ensure the correct quantities for the recipe used. This must always be done, the bag weight must not be assumed.

Instruments ideally should be calibrated every six months.

4.3 Liquor Ratio

The correct liquor ratio for the recipe must be maintained otherwise incorrect concentrations of dyes and other chemicals will be present in the dye bath and the right shade will not be achieved first time.

The water gauges should be clean so that they can be easily read and should be monitored at each step during the entire dyeing process.

The liquor ratio will be altered when extra water is added to mix the dyes, the salt and the alkali. This should be factored into the liquor ratio in the recipe, i.e. if a total of 1000 L is needed but 50 L of caustic soda will be added, then the volume of water initially put in the dye bath should be 950 L.

4.4 pH Control

The pH must be measured after the alkali (e.g. soda ash) is added to ensure that it is the same as that specified in the recipe. Different dye types require different pHs and the recipe should account for this but in general pH must be within pH 10.5-11.5 (see Chapter 2).

4.5 Temperature Control

Different dyes require different temperatures and times for optimal dyeing. The recipes are created to ensure that the best conditions are used for each dye. It is therefore very important that these temperatures are maintained for the correct period of time.

Some machines might take a longer period of time to reach the temperature required. These should be monitored and adjusted so that the required time to reach the right temperature is maintained. Records should be kept of any changes.

Summary

Improving efficiency and saving money in textile dyeing need not be expensive. Simple changes to procedures and housekeeping can save considerable amounts of money. Taking the time to observe process inefficiencies, calculate financial losses from these inefficiencies and make plans to correct them can do a lot to improve the competitiveness of a factory. It will also reduce pollution.

This booklet has been put together to give a brief and straightforward introduction to "alternative" or "cleaner" production options for dyeing cotton with reactive dyes in winch-dyeing machines. It is not a comprehensive manual but is one in a series of booklets that cover various aspects of the dyeing industry, including efficiency, cost reduction, pollution mitigation, effluent treatment, environmental legislation, health and safety, and corporate responsibility. This booklet covers some basic principles about reactive dyes and the optimal conditions for their use, to increase efficiency, save money and reduce pollution. All options set out in this booklet are low- or no-cost options that can be easily implemented and for which cost savings will be quickly seen. The booklet also provides examples that enable factories to calculate their own potential cost savings from implementing the suggested changes.

The booklet has been written by a team from, the Stockholm Environment Institute (SEI), the Bangladesh Centre for Advanced Studies (BCAS) and the University of Leeds, for the "Managing Pollution from Small- and Medium-Scale Industries in Bangladesh" project. The work was funded by the UK Department for International Development under its Knowledge and Research Programme, and the Government of Bangladesh under the pollution component of the Investment Support to MACH. However, the views and opinions expressed here are not necessarily those of the funding agencies.

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