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DEVELOPMENT OF HOSIERY AND KNITWEAR INDUSTRY, LUDHIANA, PUNJAB (PHASE II)

DP/IND/82/006

INDIA.

Technical report: Providing technical advice on yarn dyeing in the pilot dyehouse at the Knitwear Facility*

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of G. Meier,
Expert in textile dyeing and finishing (multi-fibre dyeing)

United Nations Industrial Development Organization
Vienna

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Summary of Recommendations:

- Pegg GH machine - repair of leaking valves;
  - introduce appropriate cleaning practices.

- Install two dye mixing bowls.

- Install hydraulic press for loading dye cans with wooltops.

- Obtain stainless steel buckets, waterhose pipe, 1000 cc beakers and cylinders.

- Obtain a jet dyeing machine.

- Produce dye-packages of uniform weight (winding).

- Install a step down transformer on the Dyetex machine.

- Apply the dyeing procedures as demonstrated by the expert.

To resume his earlier interrupted mission, the expert set out from his hometown on 5 April 1985 arriving at New Delhi on 8 April 1985, after a short briefing at UNDP office by Dr. Kamal Hussein, the expert called on the Managing Director of Punjab State Hosiery and Knitwear Development Corporation (PSHC) at Chandigarh on 9 April. Detailed discussions were held with the Managing Director who laid out the following specific tasks for the expert:

1. Dyeing of Acrylic Materials

Established level dyeing, train the project staff to carry out such dyeings on a continuous basis, rectify the problems associated with level dyeings of acrylic materials.

2. Dyeing of Wool

Establish dyeing methods for five specific shades to Woolmark standard. Review recipes and methods, recommend measures for cost reduction, productivity and housekeeping.

3. Cotton Dyeing

Thirteen specific shades to be accomplished.

4. Quality Control and Workload

Review and make recommendation on present quality standards and workloads.

5. Dyetex Machine

Commissioning.

The expert left Chandigarh on 9 April and resumed his assignment at Knitwear Facility, Ludhiana on 10 April.

Work Done

1. Dyeing of high bulk acrylic yarn in hank form:

The first batch of acrylic yarn of high bulk type, 2/32 Nm, was dyed in the Pegg GH machine, in a pink shade using a new method of dyeing "Continual boiling process". The method comprises bulking and dyeing at the same temperature. After completion of the dyeing process it was observed by the expert that dyeing was not level and the penetration of the dye uneven. To rectify the dyeing fault the expert, examined the dyeing machine, dismantled the dyeing arms, cleaned the circulation inserts, removed the false bottom of the machine, cleaned the circulation pump and motor shaft etc. On restarting the machine much better liquor flow was achieved. Similar exercise was carried out for the second machine, additionally all the spare yarn carriers were cleaned in both machines. Full training was given to the machine operator in correct method of loading the yarn hanks on dyeing spindles.

Another trial with the same colour was carried out using a different process, in which the bulking of yarn was carried out in an autoclave, and then dyeing in normal way, the result was quite satisfactory. The process however is comparatively costlier as the material is to be handled twice.

The faulty material from the first trial was redyed by the normal method using a darker shade and the result was satisfactory. The trial using "continual boiling process" was repeated on another batch. The following technique was used:

> The bulking of yarn was carried out in the dyeing machine, firstly by taking half the quantity of required water, and raising it to boiling temperature. The steam was then turned off and the material was lowered in the bath very slowly, kept immersed for 10 minutes, then the pump was started, cold water was added to bring the temperature of the bath to 70°C. Dyestuff and auxiliaries were added at this stage and the machine run for 10 minutes. The temperature of the bath was then raised to 85°C, machine stopped for 10 minutes. After which the bath temperature was raised to boil and the machine run for sixty (60) minutes. Afterwards the temperature was brought down to 50°C, very slowly 2% softener were added, machine run for 25 minutes and the material then hydroextracted. The results were quite satisfactory.

Programmed training has been given to staff and operators in housekeeping of dyeing machines. Acrylic dyeings heavily stain the machines, therefore the dyeing should be carried out from light to dark shades and then to lighter shades. For dyeing with optical brighteners it is necessary that the empty carriers of the machine are boiled out (i.e. stripped) with caustic soda and hydrosulphite. Only this way very white effects can be obtained. This was demonstrated to the staff by the expert.

Twelve new shades for babywear were developed for M/s Rosy Knitwear. The yarn for the purpose was specially treated for softwear. The samples were very well accepted by Mr. B.M. Kalra the owner of M/s Rosy Knitwear.

When examining the acrylic hank dyeing machines it was noted that water valves were leaking, which could cause serious faults in dyeing of acrylics. It was pointed out to the maintenance staff and it is expected that the faulty water valves of no. 1 and no. 2 machines will be changed/repaired in due course.

1.1 Dyeing Instructions for High-Bulk Acrylic at a Continual Boiling System to Obtain Maximum Leveiness

i) Preparation of yarn-hanks for shrinking and dyeing:

The hanks must be shaken out to make sure no yarn crinkles are left, otherwise you will set them during bulking process.

The yarn hanks have to be placed evenly to prevent channeling during dyeing.

ii) Set dye bath:

Fill machine with plain water heated to 60°C, pump on and add

5% Glauber salt
1.5% Acetic pH 4 - 4.3
1.5% Non-ionic levelling agent

Raise Dye-bath to 80°C
Add with Pump on

X% Dyestuff
X% Retarder

Raise Dye-bath to boil

Run for 10 minutes. Turn off steam and circulation pump. Enter acrylic material very slowly as demonstrated. Turn back on circulation pump and steam, boil for 60 minutes.

Sample
For very deep shades add
1-2% sodium acetate

Of all synthetic fibres used in the textile industry, the acrylic fibre is possibly used in the largest quantity due to its high bulkiness, soft handle, wool like feel, brilliancy of shades and colour fastness properties. It is not only used for apparels, also used for carpets and furnishing fabrics etc. In general cationic dyes are used for dyeing of acrylics. The dyer has to be careful in selecting of cationic dyes, the dyes of same K values should be selected to get the proper saturation value and for trouble free level dyeings.

It is necessary to take care of the following factors, for obtaining level dyeings on acrylic fibres:

i) Control of dyeing temperatures:

Control is to be exercised in raising the dyebath temperature. Proper programming is to be done and extra care is to be taken near 80°C. The expert has trained the Knitwear Facility (kF) staff to stop at 80°C for 15 minutes. However in practice it is not sufficient to control the dyeing temperature only to get level dyeings.

ii) Addition of cationic retarder:

To obtain level dyeings on acrylics it is necessary to add to the dyebath a cationic retarding agent having high affinity and easy diffusion properties. It is important to use the right quantity of the retarder, for dyeing of pastel shades a higher quantity of retarder is used than for medium and dark shades, for example:

Pastel shades - 2 to 2.5% retarder
Medium shades - 1 to 1.5% retarder
Dark shades - 0.3 to 0.5% retarder

Eventhough the retarders are expensive and add to the cost of dyeing specially in case of pastel shades, it is advisable not to compromise on the use of its required percentage, to avoid unlevel dyeings, which may lead to rejection or redyeing of lots.

iii) Addition of salt:

To retard the rapid absorption of cationic dyes by acrylic, 5-10% of Glauber salt are added to the dyebath, but its action is less effective than that of cationic retarding agents.

iv) Addition of Nonionic levelling agent:

Should also be added to the acrylic dyebath.

v) Softeners:

A cationic softening agent in excess of 2% should be used for acrylic dyeing. If the fibre is to be used for baby-wear, 3% softener is required to be added, i.e. 1% in the dyebath and 2% after completion of the dyeing process.

Further trails have been taken in the KF Dyehouse, by the above techniques, the results were very satisfactory and the dyeings completely faultless. The processes were fully demonstrated to the KF staff.

2. Review of recipes and methods:

Trials were carried out in the Knitwear Facility (KF) in dyeing of Woc .tops with the objectives, cost reduction and higher productivity, through faster dyeings in shorter dyeing time. The following process was followed to carry out the trials:

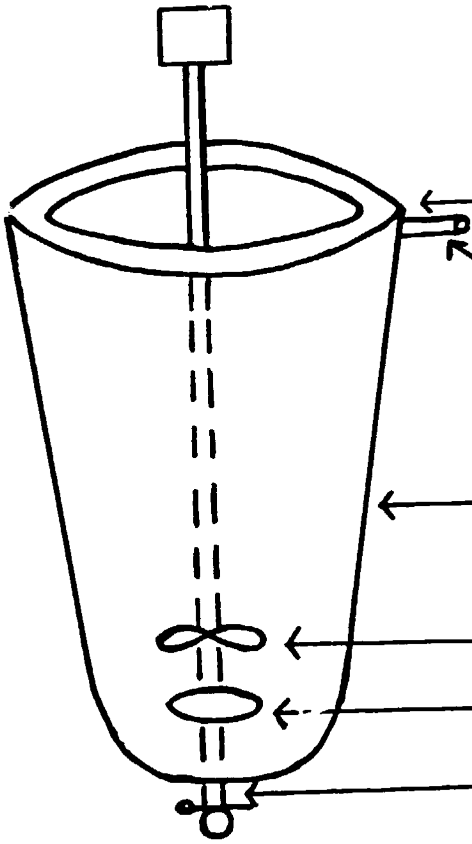
- No scour, 10 minutes wetting out at 45°C, add chemical and dyestuff, hold the temperature for 10 minutes, raise temperature to 70°C, hold for 10 minutes, raise to boil, run for 45 minutes, sample, two rinses, finish.

The trial was repeated on large scale at Oswal Woollen Mills at their request. The trials were quite successful, which were carried out in presence of KF Dyeing Master and the staff of Oswal's dyehouse. The results of the trials were well accepted by all. Oswal's dyehouse has a capacity of 1600 kgs of Wooltop dyeing in three shifts. By the new method of dyeing the unit will be in a position to produce 2,500 kgs in three shifts with considerable savings in terms of chemicals, power, water and labour etc. There is marked improvement in the quality of material. The expert has demonstrated to the party that the felting of top sliver is much reduced by this method (i.e. shorter dyeing cycle).

2.1 Cost reduction in dyeing through improved practices:

Presently dyes are mixed in KF dyehouse upstairs and conveyed to machines in buckets. This practice is not only dangerous, it is also very uneconomic and wasteful. While carrying the dyeliquor in 4-6, full 5 gallon buckets, there is considerable loss of dyeliquor from the buckets due to spillage. This is a costly practice as it results in off shades in dyeing, extra labour, stained floors, wastage of steam and dyeing time etc.

Hence the expert recommends that two dye mixing bowls are installed, one each in cone dyeing (upstairs) and hand dyeing (downstairs) sections. A sketch of dye mixing bowl is given below for reference:



25-30 Gallon Capacity

2.2 Dyeing of wool in package:

Two sets of fashion shades of Woolmark standards were developed, the standard (dry-clean) category and the other the shrink-resist category. All shades, viz. Maroon, dark green and navy blue were dyed using Acidol dyes. The dyeings conformed to IWS Woolmark specifications. The method of dyeing used is technically the best and the expert is confident that if the method is followed properly there would be no problems in dyeing of these shades at KF in future.

It is known that with 2:1 premetallised dyes in full depths, it is not possible to achieve Superwash wet fastness standards. The expert has demonstrated to the KF staff that by combining ACIDOL M dyes with reactive dyes, the dyeings obtained, give maximum wet fastness mainly in shades of Maroon, dark green, navy and brown. This combination neither involves any extra cost or skill. The expert recommends that as per the modern practice, the KF should carry out dyeing of chlorine-Hercosett treated wool in top form as it has the advantage of:

i) Saving the cost of winding and rewinding;
ii) No effect of winding density, on dyeing;
iii) Possibility of blendings;
iv) Improvement in washfastness property of dyed material;
v) Cost saving through bump-top dyeing.

As the KF's Spinning Plant is now operationable, the expert is of the opinion that the KF should go in for top dyeing of wooltop. The equipment is already there and the only extra expenditure involved will be that of obtaining a hydraulic press for loading the dye cans. Keeping this in mind the expert has provided the necessary guidance to KF staff and demonstrated top dyeing at KF and at M/s Punjab Woolcombers, Ludhiana. The procedure of dyeing of clear and brilliant shades with ACIDOL M dyes is given in the Appendix I of this report.

The KF dyehouse urgently needs stainless steel buckets, waterhose pipe, 1000 cc beakers and cylinders, this has been conveyed to the Works Manager for action. Presently plastic buckets are used. Plastic buckets are not dye consistent and gets heavily stained. Use of stained buckets for other colours give rise to problems like dyespots and discolouration etc.

3. Cotton dyeing:

The expert guided the KF dyehouse staff in carrying out dyeing of cotton in various shades using reactive dyestuff. The black shade presented some problem of dye fixation, this was rectified. The expert observed that the yarn received at the KF for dyeing from clients is sometimes not in good condition, and the yarn tenacity varies considerably, from lot to lot. The package density variation in winding of cotton yarn also causes some problems in dyeing.

3.1 Dyeing of polyester-cotton fibre blends by "Levametering process":

The increasing importance of polyester-cotton fibre blends has created the demand for economical dyeing methods with reactive and disperse dyes. It is expected that the consumption of polyester fibre will increase worldwide at the rate of [illegible] per year, whereas the volume of consumption of cotton will be about [illegible]%. The percentage of polyester staple fibre content of polyester/cotton fibre mixture will increase. It is estimated that in 1985, 64% of total polyester fibres and 16% of cotton fibres produced will go in blends. The consumption will depend on regional differences, it is likely to gain more importance in the far-east and North American markets.

Before going into the details of Levametering dyeing of polyester/cotton blends, the expert will compare the two-bath, one bath pH gliding and one bath Levametering processes. By the number of dyebaths it is meant that in the two bath process two separate baths are used for pH gliding and Levametering (controlling of caustic soda solution in the dyebath). In the single bath and Levametering processes only one bath is used.

3.2 Labour saving:

The more additions to be made to carry out a dyeing the more labour intensive the process is. In case of the two baths process a larger number of additions are necessary in the comparison of pH gliding process which is a one bath process, and the Levametering process which is a one bath two step process. Energy and water consumption in the case of two bath process is higher than the single bath processes.

3.3 Cost of chemicals:

The pH gliding method requires a buffer salt which is more expensive than caustic soda or soda ash used in the other two processes. Good dispersol dyes and selected reactive dyes are used for these processes. Dissolving of soda ash is somewhat mere complicated than that of buffer salt or caustic soda.

Dyeing time is linked with the productivity. Reproducibility is important. pH gliding is an "all in" process and Levametering is an automatic process and is not much influenced by variables, such as manual activities. In one bath pH gliding method buffer salt regulates the fixation of reactive and disperse dyes in conjunction of temperature and time. The addition of dyes and or alkali in the Levametering process is programmed and electronically controlled. All these functions influence levelness and reproducibility of dyeing and dyestuff yield.

This new method of Levametering dyeing is very economical, besides being having very good reproducibility. The expert has discussed, the full scale process with the KF Dyeing Master, in view of the possibility of KF receiving a badly needed Jet Dyeing Machine. A full process description brochure has been given to the KF and the expert is confident that the Dyeing Master of KF will be in a position to use this modern cost-saving development in dyeing.

4. Quality control and workload in dyeing:

Yarn Packages: It is well known that the yarn packages vary in weight and outside dimensions within the same lot of yarn packages. As per the manufacturers of winding equipment within one dyelot the individual packages could vary in net weight within the range of ± 5% of the mean value, and this is the best result one can expect even while using the best winding machinery.

The expert has found that in reality at the KF, the individual weights of packages for dyeing vary between ± 10 to 20%. To obtain uniform dyeing on packages it is very important that the variation does not exceed ± 5%, specially in case of cotton and acrylic materials. It is very important that every element of volume of yarn in packages per time unit is covered by the same quantity of dyeliquor. The problem has been discussed in detail with the Winding and Dyeing Masters of KF to impress upon them the importance of the point.

4.1 Making of proper dye solutions:

The dyeing process is successful when proper dyestuff solution is fed to the dyeing machine. To get even and spot free dyeings it is necessary that the dyestuff and auxiliary solutions are free from undissolved particles and foreign matters. This can be achieved through filtering the solutions with cotton cloth. The importance of this point has been discussed with the KF staff and the Technical Coordinator. The expert advised them to see that sufficient stock of cotton cloth is kept in the dyehouse store, to strain dye liquors. The expert has also discussed with the KF Engineer the possibility of making a simple and cheap straining sieve for filtering dyeliquors. A design for the same has been provided and it is expected that the device will be ready in due course of time.

4.2 Winding cost:

The expert has observed that upto 10% material is rewound to avoid faulty dyeings, the matter has been discussed with KF staff.

4.3 Training:

i) The expert has been provided the KF a special guidebook on the subject of training of the personnel of dyehouse.

ii) Fellowship training: The expert has made arrangements for a 4 week fellowship training of Mr. Jasbir Singh, the Assistant Dyeing Master of KF at M/s Levana Jersey Fabrics Ltd., P.O. Box 372, Levine, New Zealand. The company has a modern dyehouse equipped with Jet dyers, high pressure and atmospheric pressure yarn package dyeing machines, circular dryers, winches, dry cleaning and express units.

The expert has received confirmation from Levana Fabrics, that they are agreeable to accept Mr. Jasbir Singh for training in their organization.

5. Commissioning of Dyetex machine:

The machine was examined with the assistance of the KF Dyeing Master and the electrical engineer of Zinser and Company. The machine when put 'on' worked for a very short period and then automatically switched off, caused by too high input of electrical current. The recommended power input is 3 x 380 V/50HZ whereas the current being fed to the machine is 3 x 440 V, which causes over-powering of the machine activator (distributor). The expert therefore recommends that a step down transformer is installed to provide the machine with the required power supply (3 x 380V). Otherwise it may not be possible to run the machine without damaging its distributor. It is also suggested that the opinion of a specialist in electricity/electronics is also sought before purchasing the transformer.

The expert regrets the non-commissioning of the Dyetex machine as the local electrical technician has not visited till the time of writing this report.

Visits to Units

i) The expert alongwith the KF Dyeing Master visited M/s Shiroga Knitwears, to advise them on their problems of pilling and dyeing of polyester/cotton blends.

ii) Further visits were made to M/s Punjab Woolcombers Ltd., in connection with modernisation of their wool top dyeing process. The expert has recommended them to use "SUSTILAN N" which is an agent for protection of wool fibre against shrinkage. The party has arranged to import it as per the expert's advice.

iii) The expert also visited M/s Greatway to advise on dyeing of wool-tops.

Combistenter (Kurt Ehemann): The machine is under erection at the time of writing this report. The expert will carry out some trials if it is ready before he leaves. Its operation has been discussed with the Processing Manager of KF.

General:

Further trials were made at the KF on dyeing of high bulk acrylics by various processes. The expert is confident that if the KF dye-house staff proceeds as demonstrated and follows the instructions of Dyeing master, extremely satisfactory results in dyeing of high bulk acrylic will be obtained.

The expert has made certain recommendations to the Works Manager of the KF for smoother running of the dye-house, which he has assured to be implemented, the expert feels with their implementation there will be definite improvement in the technical performance of KF dye-house.

Acknowledgement:

The expert would like to thank the staff, especially the Processing Manager of the Knitwear Facility for their excellent co-operation.

APPENDIX I

Dyeing of Clear and Brilliant Shades with ACIDOL M Dyes

General Information

Acidol M and Acidol X dyes are applied in a weakly acid bath together with Uniperol SE as dyeing auxiliary.

It should be noted that certain Acidol X dyes, those with activated reactive groups, have a very high degree of fixation and the fibre-dye bond is irreversible. They should therefore go on to the fibre uniformly, even in the heating-up phase, because unlevelness in the boiling phase can only be corrected with difficulty and considerable effort. For this reason, with pale and medium shades we recommend that the heating-up be discontinued for 10-15 min. at 70°C.

In addition, attention should be paid to the fact that the exhaustion (speed and degree of fixation) is also influenced by the pH. The higher the concentration of hydrogen ions in the dyebath, then the more rapidly and completely do the dyes exhaust onto the fibre. Dyeing must therefore be carried out in different pH ranges, according to the amount of dye used. Depending on the depth of shade, we recommend setting the pH as follows:

Dye	upto 1.0%	1-2%	2-3%	above 3%
pH	6.5-6.0	6.0-5.5	5.5-5.0	5.0-4.5

As the degree of fixation is also dependent on the pH, it is particularly important with combination dyeings to maintain these values as exactly as possible in order to ensure good reproducibility of shade.

Procedure

The pattern illustrated were bleached and dyed according to the following recipes:

Bleaching

Rapid bleach in a long liquor

0.5 g/l Kieralon OL
4 g/l Prestogen W Liquid
20 ml/l hydorgen peroxide 35%
45 min. at 60°C
Rinse
1 g/l Basopal OP
5 g/l Blankit IN
60 min. at 60°C
Rinse; add
1 ml/l hydrogen peroxide 35%
to the final rinsing bath.

Dyeing

0.7 g/l Leophen M
5 % ammonium sulphate / pH 6.5-4.5 depending
... ml/l acetic acid 60% / on depth of shade
0.5-1 % Uniperol SE High Conc.
... % Acidol M or Acidol X dye
Liquor ratio 20:1
Add ammonium sulphate, acetic acid, auxiliaries and dyes with the dyebath at 40°C.
With dark shades, heat up to the boil in 60 min.
With pale and medium shades interrupt the heating-up for approx. 20 min. at 70°C before raising the bath to the boil.
Dye at the boil for 45 min., depending on depth of shade.
Cool down, rinse.

Information Concerning the Dyeing Auxiliaries

Leophen M

Leophen M, which is added to the dyebath first, de-aerates the material and aids wetting out. It also acts as a foam repressant.

Uniperol SE

Because it is an amphoteric product, Uniperol SE is both fibre - and dye-affinitive. It promotes uniform exhaustion of the dyes and also acts as a levelling agent.

Higher amounts lower the affinity, so that it can also be used for subsequent levelling out or lightening.

Concentrations employed:
0.5-1.0% Uniperol SE High Conc. or
1.0-2.5% Uniperol SE
as levelling agents.

1.0-2.0% Uniperol SE High Conc. or
2.0-4.0% Uniperol SE
for levelling out or lightening.

Shading

Acidol M and Acidol X dyes can be used for shading purposes. Before they are added, the dyebath is cooled to approx. 60°C and approx. 5 min. after the dye addition it is heated up again over 30-40 min. to the boil. Dyeing is then continued for a further 20-30 min. at the boil.

After treatment

In order to achieve optimum fastness properties, all dyeings with more than 1.0% dye should be after-treated with

1 g/l Kieralon D
3 ml/l ammonia 25%
for 20-30 min. at 50°C.

Correction of faulty Dyeings

Levelling out and lightening

Dyeings that are too full, or which are somewhat uneven, can be levelled out or lightened by treating them for one hour at the boil or 30 min. at 103-106°C in a fresh bath, set to pH 6 with acetic acid, which contains

1-2 % Uniperol SE High Conc. or
2-4 % Uniperol SE and
5 % ammonium sulphate.

To what extent the dyeings can be lightened is dependent on the depth of shade. Under the conditions stated, it is possible to lighten dyeings with Acidol M and Acidol X dyes by up to 10% or more.

Stripping

Depending on the depth of shade and the particular dye used, dyeings with Acidol M and Acidol X dyes can be stripped, either partially or almost completely, by treating them with

5 % Deflavit ZA
2 % formic acid 85%
2 % Uniperol SE

for 30 min at 90°C. The material is then well rinsed, warm and cold.

APPENDIX II

Selection of Dyestuffs for Fibre Types

There are two main groups of textile fibres: natural and man-made fibres.

Let us look at the fibres that make up these groups and the classes of dye that can be used to dye them.

Natural Fibres:

Animal	- Wool and Hair fibres	Sheeps wool Cashmere Mohair Alpaca Vicuna
	- Cocoon fibres	Rabbit Camel Silk
Vegetable		
	- Seed fibres	Cotton, Kapok
	Bast fibres	Flax, Jute, Hemp, Ramie
	Leaf fibres	Manilla, Sisal
	Fruit fibres	Coir
Mineral		
	- Man-made fibres	
	Natural starting point	
	Rayon	Viscose
	Cellulose Acetate	Secondary Acetate Triacetate
	Algenate fibre	From Seaweed
	Silica fibre	
	Synthetic starting point	Polyamide Polyesters Polyacronitrites Polyvinyl Alcohol " Chlorides Polypropylenes Polyurethanes

For convenience in studying dyeing properties, the fibres can be broadly divided into:

Cellulosic: Cotton, Linen, Jute, Viscose, Rayon, Polynosic.

Protein: Wool Hairs, Silk.

Synthetic: Polymer Fibres - Cellulose Acetate, Polyamides, Polyesters, Acrylics.

In our study of dyeing we are considering that application where the transfer is taking place in acqueous solution. As all chemicals when placed in water split up into positively and negatively charged particles (Ionise) some greater than others. Dyes also ionise and thus can be classified into a particular class depending on the charge of the coloured Ion (Chromophore).

Positively charged - Cationic or basic
Negatively charged - Anionic or Acid

A major group of dyes are virtually insoluble in cold water (that is the amount they Ionise is very low). These are known as disperse Dyes - Dispersion of the Dyestuff in water.

However at the dyeing temperature they are thought to solubilise and behave like Anionic Dyestuffs.

Another group are insoluble in water until reduced by a reducing Agent then oxidised back to their insoluble form once on the Fibre-Vats. In still a further group two single soluble components are applied to form a coupled insoluble form - AZOICS.

Now let us look at the various Application Classes of Dyes.

Acid Dyes

These Anionic Water soluble dyes are used to dye all protein fibres, Polyamides and some Acrylic fibres which have been modified with a basic monomer.
They provide an extensive shade range and ease of application. On wool they are divided into two groups:

i) Level Dyeing Acid Dyes - applied from a strong Acid Bath (Low pH), have excellent levelling properties (Migration) however relatively poor wet fastness.

ii) Acid Milling - applied from a weakly acid bath (higher pH), have poorer migrating properties but excellent fastness to wet treatments.
Acid dyes combine with the sites in the fibre by Ionic forces which are reinforced by van der Waals Intermolecular forces (especially so in Acid Milling Dyes).

Chrome Dyes

Are Anionic water soluble dyes for all protein fibres and Polyamide. Mainly used on Wool, very similar to Acid Dyes however they have additional groups which allow the reaction with a metal Ion (usually Chromium) - Mordanting.

The Metal Ion can be applied prior to the Dyestuff - Chrome Mordant or as an after treatment - after chrome (more common). They are applied from a weakly acid dyebath and have excellent fastness both light and wet.

The chrome complex formed in the Fibre is insoluble and cannot easily leave the fibre. The shades of chrome dyes are not particularly bright and mainly used for neutral shades and black.

Premetalised Dyes

Anionic water soluble dyes for all protein fibres and polyamide. Similar to Acid Dyes in some ways, however they have a Metal Ion one to one (1:1 Premets) or 2 Dye to 1 Metal (2:1 Premets) chelated to the Dyestuff in manufacture.
1:1 Premets are applied from a strongly Acid Bath, very good levelling and excellent fastness.
2:1 Premets Weakly Acid Bath, very good levelling and excellent all round fastness.
Good shade range however also not particularly bright.

Reactive Dyes

Anionic Water Soluble Dyes for Cellulose, Protein and Polyamide fibres. These dyes form covalent bonds with the fibres which give rise to excellent fastness, especially wet.

Wool Reactives - these are applied similar to Acid Milling Dyes but the use of levelling agents is important to help apply the Dyes Level as once the Covalent Bond is formed then no further levelling can occur. These Dyes can also be applied to Polyamide Fibres upto certain depths of shade.

Cellulosic Reactives - form covalent bonds with the Hydroxyl Groups in Cellulose. Substantive in the presence of salt and the dye - Fibre reaction is promoted by Alkaline conditions.

Excellent shade range.

Basic Dyes

Cationic water soluble dyes originally used on protein fibres and by the use of a mordant on Cellulosics however they exhibited poor light and wet fastness.
Modified forms of the original basic dyes are used to dye Polyacrylonitile fibres to a very high fastness and wide range of shades. Applied from an Acid Bath (pH 5) in the presence of salt and retarding Agents to help slow down their exhaustion.
Extensive shade range available.

Disperse Dyes

Water insoluble dyes, which show some Anionic character because of presence of dispersing agents, used on Polyester, Polyamide. Polyacrylonitrite and Cellulose Acetates.

The Dyes are applied from an Aqueous Dyebath containing Dispersing Agents (help keep the dye stable in dispersion) and Acid. (In the case of Polyester Fibres a carrier is necessary at the Boil, or temperatures above 100°C to promote diffusion of the Dye). Modern theory suggests that disperse dyes have small solubility at dyeing temperatures and the soluble form is responsible for dye transfer.

Direct

Anionic water soluble dyes for Cellulosics. Large flat Planar Molecular structure and have Affinity for Cellulosic Fibres from a simple water solution, however Dyeing is assisted by the addition of Electrolyte.

Direct dyes classified into three groups:

A - Good Levelling, not salt sensitive;

B - Poor Levelling, slight salt sensitive;

C - Poor Levelling, salt sensitive.

Direct Dyes on Cellulosics only have moderate wet fastness, which can be improved by after treating with cationic fixing agents, Formaldehyde, and copper salts according to the dyes used. Good range of shades available.

Vats

Water Insoluble Dyes for Cellulosics. Applied to the Fibre in a soluble form by reducing the Dyestuff in the presence of Sodium Hydrosulphite and Caustic Soda, this state is known as the dyes "LEUCO FORM". In this state the Dyestuff possesses high Affinity for Cellulosic Fibres.

Finally the Dye is restored to its original insoluble form on the Fibre by Oxidising with air or oxidising agents then soaped off at the boil to Agglomerate the small dye crystals into larger forms which are firmly locked in the fibre structure. Vat Dyes have outstanding fastness and excellent shade range. Can be applied to the Fibre by:

a) Dispersed Insoluble Form deposited on the Fibre then reduced to LEUCO Form and finally Oxidised.

b) Dye with LEUCO Form then Oxidise.

There are also ranges available which have been reduced in manufacture "SOLUBILISED VAT DYES". However, these do not give Dyeings to the same fastness as normal vat dyes.

Sulphur

Water Insoluble Dyes for Cellulosics. Contain Sulphur Linkages in the Dye Molecule. Converted into soluble substantive LEUCO compound by reducing with Alkaline sodium sulphide. Once dyed the LEUCO form is reconverted to the insoluble form by exposure to air or oxidising agents.

Very good wet fastness mainly subdued shades and blacks.

Azoic Dyes

Water Insoluble Dyes used for Cellulosic materials and for Black on Polyamide, Polyester and Acetates. These Dyes are formed in the Fibre itself by the chemical reaction (coupling) between two soluble substances (the coupling component and a DIAZO component). The Insoluble product thus formed gives a wide range of bright fast colours. Mainly used to supplement the Vat Range in the Orange, Red and Scarlets and for Blues on Canvas materials.

Oxidation Dyes

Only member of this range important in textiles is Aniline Black. Water Soluble Aniline Hydrochloride is applied to the Fibre then oxidised (usually in the presence of Acid and Sodium Dichromate) to an insoluble form. Soaping at the Boil finally develops the colour. Mainly used in printing.

Ingrain Dyes

Small group of Dyes (Phthalocyanine Derivatives) composing two subgroups for Cellulosics:

i) Cationic Water Soluble Form which is substantive to the Fibre but is then insolubilised by removal of the solubilising group by boiling with Alkali.

ii) The insoluble Phthalocyanine Pigment is synthesised within the Fibre.

Pigments

With certain synthetic Polymer Fibres very finely dispersed Pigments can be incorporated in the Fibre Melt before extrusion into the Fibre Filament. These Dope-Dyed colours are extremely fast and used mainly in Blacks on Polyester.

Thus the Dyer has on hand many ranges for Dyestuffs available for colouration of Textiles and the choice can be influenced by many factors

i) What form of material to be dyed - yarn, piece, loose stock, sliver.

ii) What machinery is available - if good circulation, then level dyeing character is not so critical.

iii) Fastness requirements - both in processing and in final form.

iv) Economy.