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GENERAL PREPARATION PROCESSES 1/

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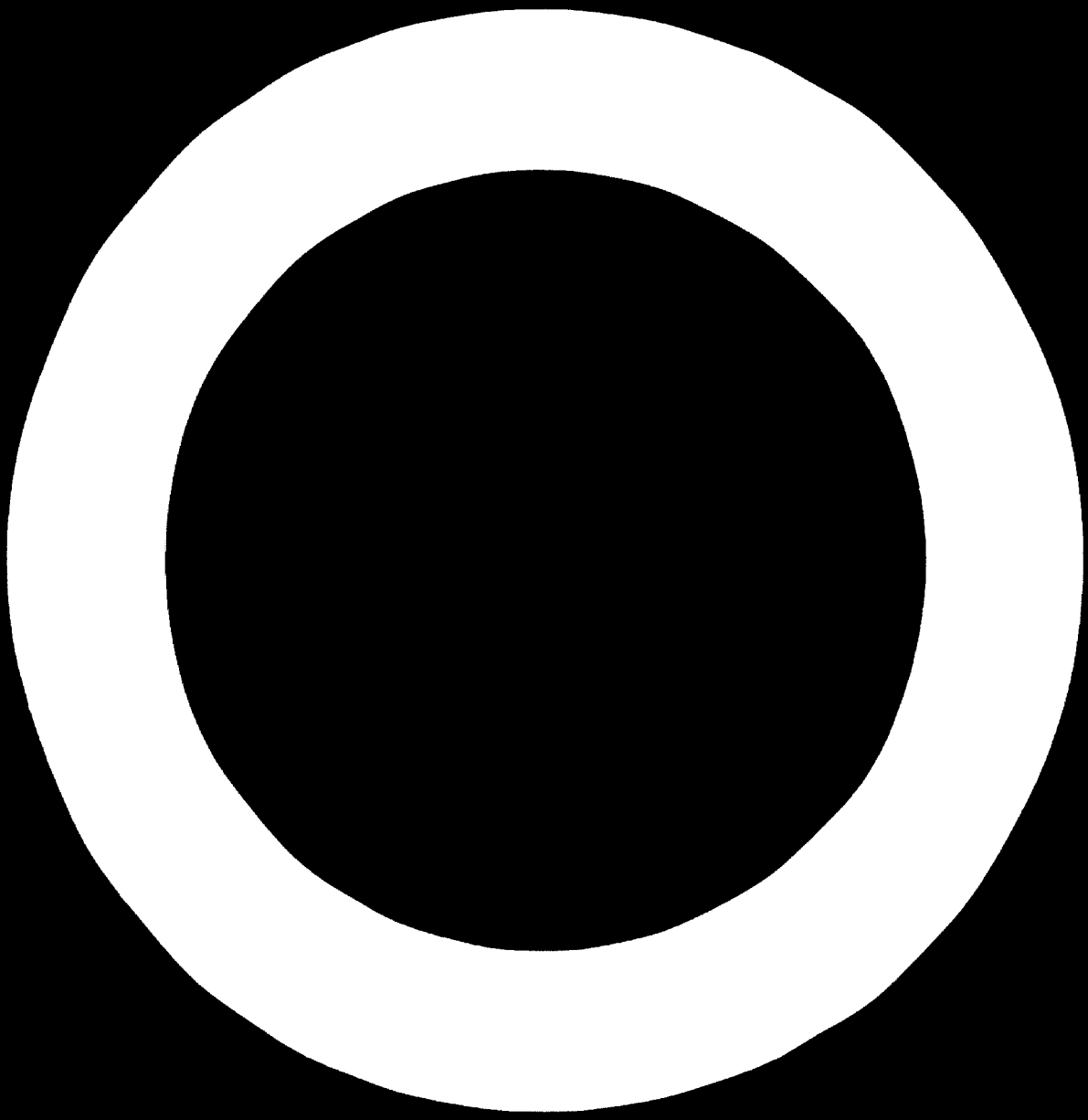


The title of my paper is general preparation processes, but what do we mean by "preparation".

One dictionary definition of preparation is "The action or special process of putting something into proper conditions for use".

I like this definition because it contains the two essential ingredients for textile preparation. First the "special process" since the preparation of fabric is becoming more and more a special process and a whole new field of technology in itself. Second "proper condition for use", this phrase is the heart of good preparation since the prime objective of the preparation process is that it presents the fabric in the proper condition for the subsequent processes of dyeing, printing and finishing.

In simple terms, the preparation process is the pre-treatment of grey fabric in order to render it suitable for consistent, reproducible fault free colouration and finishing.

Having briefly defined what we mean by preparation just how important is it in textile processing? Virtually every fabric is subjected to some form of pre-treatment and there has always been an appreciation that good preparation was important but how important? How much time and money should we spend on preparation and how critical are steps taken during preparation?

Here it would be useful to quantify the benefits gained from good preparation or perhaps, more to the point, to quantify the problems we might expect if the pre-treatment stages are faulty, variable or inadequate.

Surveys carried out over long periods of time and over a wide variety of textile dyers, printers and finishers have shown that up to 70% of all faults in the finished cellulosic or cellulosic containing piecegoods could be traced directly to insufficient or faulty preparation.

The increasing trend towards pad dyeing, the increasing demands for quality, together with the high costs of reporocessing or disposing of faulty goods means that the preparation stages are not just necessary evils, but an essential and integral part of the total process which will determine the ease and success with which all the following wet processing may be carried out.

During the last few years developments in pre-treatment have taken place at high speed and have resulted in changes in existing ideas of processing and in machinery design.

Textile dyers and finishers have become more and more dissatisfied with the conventional pre-treatment processes because of their inadequate effects, which in most cases were not attributable to carelessness or outdated machinery but rather to increasing demands on the preparation process by the dyers, printers and finishers because of developments in their technology and increasing customer demands for quality.

Experience over many years has shown that traditional batchwise processes such as kier boiling, jig preparation, pad roll and so on, are by no means ideal and have a number of inherent faults. These processes can give rise to poor reproducibility, non uniform treatment, pronounced fall in degree of polymerisation and strength of fabrics and catalytic damage.

Nevertheless, these processes have been tolerated and in many cases the faults have been overcome by subsequent colouration process such as exhaust dyeing and roller printing. But as the pad dyeing and screen printing processes increased in popularity it was shown that batchwise preparation could not meet the higher requirements of dyers and printers.

Inadequate pre-treatment can also result in inferior properties after resin finishing, not only in strength but also in crease recovery and abrasion properties, due to poor penetration and distribution of the resin with the fabric structure.

The modern concept of preparation:

The main developments in the past few years have been:-

1) The trend towards fully continuous open width treatment.
2) The improvements in the alkali scouring process to an extremely effective extraction stage.
3) The increasing use of peroxide bleaching with low silicate or silicate free stabilisers.
4) The use of very short reaction times.

In the new systems of pre-treatment the processing is carried out in open width and in a continuous manner using very short reaction times.

Improvements in the chemical formulations and machinery have enabled reaction times of 1-5 minutes to be used to produce satisfactory results and this break through has led to systems ideally suited to the demands of modern preparation processes.

Short reaction times have many advantages -

- Construction of relatively small reaction chambers with relatively low investment cost.
- Low cloth capacity in the reaction chamber avoids high losses due to breakdowns, stoppages etc.
- Fabric is available for subsequent processing after only a few minutes.
- Reaction vessels can be easily designed to support the cloth in open width.

  Uniformity of processing since each metre of fabric is given the same processing conditions.
- High alkali concentration can be used without damage to cellulose or to the polyester component in blends.
- Catalytic damage minimised in peroxide bleaching.
- Reduced difficulties with problems arising from silicates in peroxide bleaching.

The short reaction times involved in many of the modern pre-treatment processes mean that we must ensure maximum effect at each stage of pre-treatment in order to obtain the final objectives of preparation.

- Good absorbency
- Good whiteness
- Good seed removal
- Minimum damage
- Even treatment
- Freedom from creases

Considerable quantities of impurities from various sources have to be removed from the fabric and these can be divided into 3 groups:-

1)	Natural Impurities -	Fats and waxes Pectins Cotton seed Oligomers	5-10%
2)	Processing Aids -	Spinning oils Sizes Weaving lubricants	10-15%
3)	Pre-treatment Chemicals -	Chemicals applied to the fabric to aid impurity removal	10-15%
			25-40%

It is generally known what type of impurity has to be removed but few people are aware of the amounts present. This figure of 25-40% shows that significant amounts of impurities have to be removed and not only must the reaction conditions be such that they are rendered capable of removal, the subsequent washing processes must be capable of removing them. This point must also be borne in mind when considering water and energy savings by reducing the water usage on washing ranges.

I will talk a little more about washing later in my lecture, since it is an extremely important aspect of preparation.

Experience has shown that the aim of pre-treatment should be to remove these impurities rather than merely bleaching them and the processes available for this purpose are:-

Desizing	-	Size removal
Scouring	-	Removal of fats, waxes and lubricants
		Hydrolysis of impurities
		Seed removal
		Whiteness and absorbency
Bleaching	-	Whiteness and absorbency
		Seed removal

We must consider each process in turn, indicating the principle and the modern trend so that a total picture of a modern continuous process can be built up.

Desizing:

It is sometimes possible but not always desirable to manage without a desize as a separate operation. This depends on the material, the type of size present, the nature of the following wet pre-treatment processes since these may be capable of giving some desizing effect and finally what effect any residual size will have on colouration and finishing operation.

The desizing operation should however always be treated seriously since -

1) Certain synthetic sizes, if not completely removed, can become fixed e.g. by drying, and become extremely difficult to remove, thus creating problems at all later stages.

2) The desizing operation is normally the first wet process and the point at which the first swelling of the cotton cellulose occours. If this is carried out evenly and with full swelling all subsequent wet processing will be easier and the chances of crease marking minimised.

[redacted]

[redacted] Water Insoluble

[redacted] easily
difficultly

[redacted]

[redacted] starches which first [redacted] This can be by acid treatment or [redacted] but by far the most common method of [redacted] by degradation and solubilisation by enzymes. This operation is normally [redacted] and is traditionally a discontinuous process with the [redacted] batched on an A-frame for [redacted]

A modern development in this area is a [redacted] by padding in enzyme and steaming for very short times [redacted] at 105°C. During the steaming process the [redacted] are extremely active when heated up to 100°C and the [redacted] the starch easily removable by washing, and the total [redacted] as traditional desizing and of course far more consistent since the [redacted] variability of the batch process is removed

Water Soluble:

Here the desizing operation is merely a washing process but the first point to bear in mind is that the size will not dissolve in water until it has had sufficient time to swell.

The swelling characteristics of sizes vary considerably but in general they fall into two categories:-

Easily soluble	-	Short swelling times and produce true molecular solutions
Difficulty soluble	-	Long swelling times and in many cases the solution is colloidal

The essential part of this operation is therefore to provide enough water to swell the size and allow sufficient time for swelling to take place. Unless these conditions are fulfilled the sizes will not be adequately removed by subsequent washing.

Let us consider in a little more detail the swelling characteristics of the fibre/size system using a 100% cotton fabric.

__Swelling of cotton fibres:__

When cotton fibres are immersed in water they swell and take up about 30% by weight of water. The maximum amount of water which a cotton fabric ca: pick up during padding is represented by this swelling water plus the water necessary to fill t:e air interstecns within the fibre.

The steps required to saturate the cotton fabric can be represented by -

1) Dry fabric introduced to liquor
2) Water flows into fabric and fills air space
3) Cotton begins to swell and reduces the water in the air space
4) The air space refills with water

The time [illegible] swelling to about 30 seconds so [illegible] completely saturated [illegible] the first wetting unless it [illegible] liquor for at least 30 seconds.

[illegible]

As [illegible] to swell before they [illegible] dissolve and the amount of [illegible] for swelling [illegible] on the weight of size, [illegible] having a swelling value of about [illegible]

If we consider a typical example of 100% cotton sized with a water soluble size -

Airspace volume of fibre	60%
Swelling value of fibre	30%
Content of water soluble size	10%
Swelling value of size	300%

Maximum pick up in padding(airspace + swelling of cotton) = 60% + 30% = 90%

Free flowing liquor available to swell sizes = 60%

Water required for swelling size $\frac{10 \times 300}{100}$ % = 30%

Thus after swelling the free flowing water available for solution is 60-30 = 30%

The size is fully swollen and water soluble and can go into solution.

This concentrated size solution can easily be removed during the washing off process.

This ideal situation is only possible if the fabric is allowed to take up its maximum of 90% and is allowed sufficient time for the cotton to swell.

If as is normal, the fabric is padded after singeing at high speed with relatively low contact times, then the cellulose may not swell during the padding operation and the pick up will be about 60 and of this only 30 will be free flowing. Under these conditions there is only just enough water to swell the size and there is none available for solution. However the swollen size is in a water soluble state and may still be removed if the wash off is efficient.

We are still assuming that wetting can easily take place and that during the padding process the fabric can take up 60% of water immediately, but since the fabric contains sizes and large amounts of other impurities it is not easily wettable and may not in fact take up the 60% required to swell both the size and the cotton. Under these conditions the size is not fully swollen and will be difficult to remove during the washing off. In this case the addition of selected additives will improve the desizing considerably.

I have dwelt on desizing since it does illustrate some of the points common to the various preparation stages which can become more critical as machine speeds for continuous processing increase

For all wet preparation processing we will come back to the importance of 3 separate operation.

1) Impregnation/Saturation/Liquor Interchange

2) Reaction times for chemical/physical changes

3) Removal of impurities and excess chemicals

MERCERISING:

Mercerising is a subject in itself and I do not intend to talk about its underlying principles, but it is useful to comment on its position in the preparation sequence. Mercerising confers greater chemical reactivity, improved lustre and shrinkage control and in the case of luste and shrinkage control these are only obtained if mercerising is carried out under tension.

If mercerising under tension is carried out after scouring and bleaching the fabric generally becomes less absorbent and there is a fall in whiteness.

The fall in absorbency is probably due to the effects of tension producing an even more ordered and crystalline structure than before, resulting in greater difficulty in penetration of liquids.

From a technical point of view the best place for mercerising is between scouring and bleaching since at this point the fabric is absorbent and receptive and the mercerising will be even. The after bleaching can then overcome the problems of reduced absorbency and whiteness.

However, in a continuous plant which in many cases has a tandem scour and bleach sequence, this may not be possible and the mercerising has to be carried out before scouring and bleaching.

There is a danger at this point that since the fabric is not clean and fully absorbent, that the penetration of the caustic soda will not be even and suitable wetting and penetrating agents stable to mercerising caustic soda have to be used to overcome these difficulties. This is important if the mercerising is carried out after desizing, but is absolutely essential if grey mercerising is carried out.

SCOURING:

The scouring operation can be considered as the corner stone of modern pre-treatment methods and the whole of the pre-treatment centres round this operation.

Caustic soda was one of the first chemicals to be used in processing cotton and even today it is the most satisfactory reagent for the scouring operation.

The action of the alkali scour is two-fold:-

1) Saponification and hydrolysis of fats and waxes together with the breakdown of pectins, proteins etc.

2) Strong swelling action on the cellulose giving rise to easier and quicker penetration of liquors.

Traditionally process times have been long(½ hour to 8 hours)and concentrations of caustic soda have been low(2-4%)but recent investigations have shown that for optimum scouring effects significantly higher concentrations of caustic soda can be used with very much lower times without adversely affecting the strength of the fabric.

Optimum scouring effects can be achieved in about 3-5 minutes at 105°C in steam by a suitable adjustment of recipes and judicious use of auxiliaries which aid the removal of impurities and prevent oxidative attack. Under these conditions the absorbency and whiteness of the fabric increases with increasing caustic soda concentration up to 8-10% on weight of fabric. Only above this level does yellowing and loss in strength begin to occur.

Using these optimum conditions a highly effective cleansing process is achieved in a continuous high speed running operation.

Again the three stages are equally important -

1) Enough time to apply and exchange the chemicals in a wet on wet padding process

2) Optimum reaction conditions of time, temperature and chemical concentrations

3) Efficient removal of impurities by washing i.e. optimisation of temperature and water flows

These then are the important benefits from an efficient scouring process

- Alkali scouring overcomes any faults that are produced after the desizing stage
- Fabrics which have been given an efficient scour need only a mild oxidation treatment to improve the whiteness since the absorbency is already at a satisfactory level.
  Efficient alkali scouring produces a uniform swelling of the cellulose thus reducing the possibility of uneven effects in dyeing and finishing.
- Fully satisfactory absorbency and whiteness for dyeing to medium and dark shades and for many printing operations.

BLEACHING:

In a modern multistage preparation process the objective of bleaching is to increase the degree of whiteness and to bleach or remove any remaining cotton seed. This operation should only be necessary for bright or pale shades and for white, since the fabric after desizing and scouring should already be absorbent and of adequate whiteness for many requirements.

Although many types of bleaching agents have been used hydrogen peroxide has certain properties and advantages that it has become the most common system for continuous preparation processes although sodium chlorite is used in the preparation of certain cotton knit fabrics.

The advantages of the peroxide bleach system are:-

- Good whiteness
- Excellent seed removal
- Reduced environmental and effluent problems
- Compatability with optical brightening agents
- Adaptability to short time reaction conditions
- Neutral-alkali conditions for easy combination with multistage scour processes

In traditional bleaching processes long bleaching times with low peroxide concentration have been used, but recent investigations covering recipes and stabilising systems have enabled good bleaching effects to be produced under very much shorter times than was previously thought possible.

Reaction times in the region of 3 - 5 minutes at 105°C in steam can give high levels of reproducible whiteness provided the bleaching recipes are suitably modified by increasing the levels of peroxide, stabiliser and alkali.

Under these short time reaction conditions catalytic damage due to heavy metal contamination is virtually eliminated and the stabilising system used can be modified from that used for long time bleaching systems. Reduced silicate levels can be employed in conjunction with an organic stabiliser or completely silicate free stabilising systems can be used.

These reduced silicate or silicate free systems offer improvements in the problems associated with silicate stabilised peroxide bleaching of insoluble silicate deposits adversely affecting the absorbency of the fabric.

Typical recipes operate at peroxide levels of 3-5% with sodium hydroxide at about 1% in the saturator bath.

Combination of Pre-treatment processes:

In order to fully meet the objectives of the preparation stage we have seen that it is preferable to remove the impurities rather than just bleach them and in view of the large quantities of impurities to be removed, multi-stage processing will always result in more consistent results.

In order to deal with all fabrics which a textile finisher may have to deal with the separate stages of desizing, scouring and bleaching will be required.

However, in these days of escalating costs of labour, chemicals, water, energy and effluent disposal it may be possible to obtain adequate results with only two, or even one stage processing rather than the three separate stages outlined.

Desizing can be ommitted for certain fabrics depending on type of size and provided that this does not interfere with subsequent processing.

Desizing and scouring in many cases gives adequate fabric properties for printing and medium to dark shade dyeing.

Sometimes a single stage peroxide bleach or perhaps a desize followed by a combined scour/bleach process can give adequate results.

Thus the continuous processes can be combined in different ways to give adequate properties with minimum processing and cost.

These then are the elements of modern pre-treatment processes and we have seen that in all the three stages of desizing, scouring, and bleaching reaction times can be reduced to a few minutes on a continuous basis by modification of chemical recipes and the development of auxiliaries as processing aids for short time processes.

We can now turn to the choice of plant for the application of these systems:-

Choice of machinery:

The factors influencing the choice of machinery and plant are many and varied, but I have listed one or two of the more important factors.

- Type of fabric and end use
- Total production requirements
- Control of grey fabric and sizes used
- Chemical costs
- Capital outlay
- Space requirements
- Running costs(including manpower)

A decision must also be made on whether the plant is to be rope or open width.

The advantages of rope over open width are:-

- Lower chemical costs
- High output and speed
- Will accomodate varying cloth widths easily
- Simple and efficient equipment
- Less manpower than batchwise open width processing

The advantages of open width over rope are:-

- Suitable for heavy fabrics, blends and sensitive cloths
- Particularly suitable for subsequent pad dye operations
- Chemical saturation is better and more uniform
- Less cloth is actually in process
- Better warp tension control in most cases
- Less weft distortion and surface abrasion

The trend over the past few years has definitely been towards open width processing, mainly for the following reasons:-

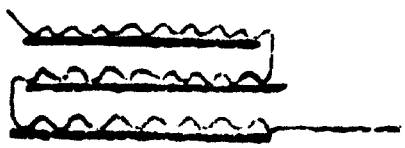
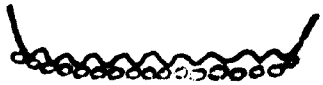
- Widening range of synthetic and blend fabrics
- Almost universal easy care crease free finishing
- Trend towards continuous dyeing and rotary screen printing
- Most developments have taken place in open width machinery making it the natural choice for new plant

On top of the trend towards open width equipment there are additional advantages in using continuous open width plant:-

- High outputs
- Better uniformity
- Easier chemical control
- Better quality control
- No cloth wastage at ends of batches
- Easy change of width
- No storage space of batches in progress
- Less labour and energy requirements
- Reduced handling
- Less cloth in progress in the machinery
- Immediate results
- Minimum chemical damage

For these reasons there has been an increasing trend towards continuous open width processing which will in my view ultimately lead to the complete abandonment of rope and batchwise pre-treatment methods.

Let us now look briefly at the types of equipment available for continuous open width processing.

- Roller steamers 
- Festoon steamers 
- Conveyor steamers 
- Roller bed steamers 
- Modified washing units 

All these systems have been used successfully and have advantages and disadvantages, for example although the roller steamer should give crease free processing because the fabric is continuously supported on the rollers, there can be problems with running creases and it is expensive to build up units to give processing times in excess of 1 minute.

Festoon steamers can sometimes give traction problems when handling highly alkaline liquors and roller bed steamers can give creasing problems.

The machinery which appears to be finding the most widespread acceptance in Europe are the roller steamer and the roller bed steamer and several different types are available from the well known machinery makers.

Until now we have talked about atmospheric steaming at about 102-105°C but it is true to say that whatever can be achieved with atmospheric steaming can also be achieved with pressure steaming at 120-140°C

Pressure steaming can also give one or two additional advantages such as

- Equivalent results in half the time
- Better seed removal
- Lower chemical costs
- Lower steam usage
- Greater chance of single stage processing

Against these advantages must be considered any disadvantages of operating under pressure from a mechanical point of view.

In addition to the steaming units considerable attention should be given to the impregnation stage since no matter how good the steaming process is, it will not be effective if there are insufficient chemicals on the fabric.

Apart from the desizing stage all subsequent processing is wet on wet.

The essential parts of a good wet on wet operation are:-

1) Reduce the water content of the incoming fabric to a low and even level by a high squeeze mangle

2) Allow sufficient time for the wet fabric to interchange with the chemical liquor. This operation needs a minimum of 7 seconds and preferably 10 seconds which at a nominal running speed of 100 metres/minute means a saturator box of about 15-20 metres cloth capacity.

3) Final squeeze must be higher than the initial squeeze, preferably by about 20% to give a final liquor retention of approximately 80%

4) The saturator liquor must be accurately controlled for chemical composition and strength so that accurate metering of chemicals onto the cloth is achieved and chemical costs kept to a minimum

Removal of impurities:

The final step in the preparation process is the removal of impurities by washing. Many of the preparation faults which arise can be levelled at the washing process which must be efficient to remove all the impurities we have gone to so much trouble to solublise.

The main factor in washing is undoubtedly the temperature which for efficient washing should be as high as practical and near the boil if possible.

It goes without saying that all modern washing ranges should be counter-flowed and fitted with heat recovery units in the waste water discharge.

There has been a lot of discussion recently on reducing the water usage, and hence the energy usage, on washing ranges and there is undoubtedly much that can be done in this area, but there is a limit to this and we must remember that we have to remove 30-40% by weight of impurities from fabric and with this in mind it is questionable if water consumption much below 6-10 litres/Kg of fabric can be achieved with current machine technology.

The use of auxiliaries in the washing liquors can give improvements in washing efficiency and I feel that there are five important features that such an auxiliary must have to be fully effective.

1.	Wetting powers	-	to aid penetration of wash liquors into the fabric, yarns, and fibres and aid surface wetting.
2.	Detergency	-	The ability to remove impurities from within fibres and yarns so that they are available for removal
3.	Emulsification	-	Liquid/liquid mechanism for removal of fats and waxes from the vicinity of the fabric into the wash liquor.
4.	Dispersion	-	Solid/liquid mechanism for removal of solids, degraded sizes and breakdowns products from the vicinity of the fabric into the wash liquor
5.	Suspending Power	-	The ability of the wash liquor to maintain emulsions and dispersions and to prevent redeposition of impurities onto the fabric.

Only when an auxiliary has all these properties does maximum benefit obtain from their use.

As a final word on washing, it is sufficient to say that unless it is carried out effectively many of the advantages available from these new preparation methods will be completely lost.

Costs:

It is difficult to be specific with regard to costs for these newer preparation methods but the following general comments are relevant.

- Capital investment in any new plant is high and installation of a continuous scouring and bleaching range would probably be difficult to justify on any works processing less than 15 million metres per annum.
- Chemical costs for continuous short time preparation are generally higher than traditional methods because of the higher chemical concentrations required. As a guide chemical costs may be 10-25% higher than some of the traditional processes.
- Labour costs are normally significantly lower than traditional methods because of reduced handling requirements and high machine outputs.
- Energy usage per metre or per Kg of fabric is lower than traditional methods because of short reaction times and optimised washing conditions.
- Money tied up in work in progress is reduced because of the short processing times.
- Better quality and consistency reduces reprocessing and faulty goods.

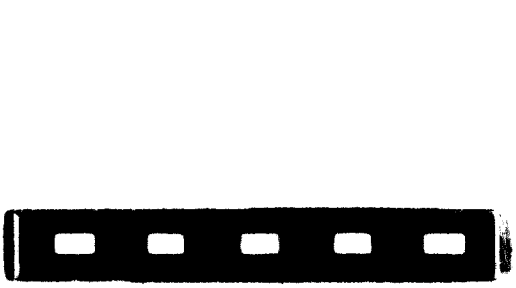
The total result of this is that these continuous methods usually result in significant direct cost savings for finishing works processing more than 15 million metres per annum, and indirect savings because of improvements in the subsequent dyeing, printing and finishing operations.

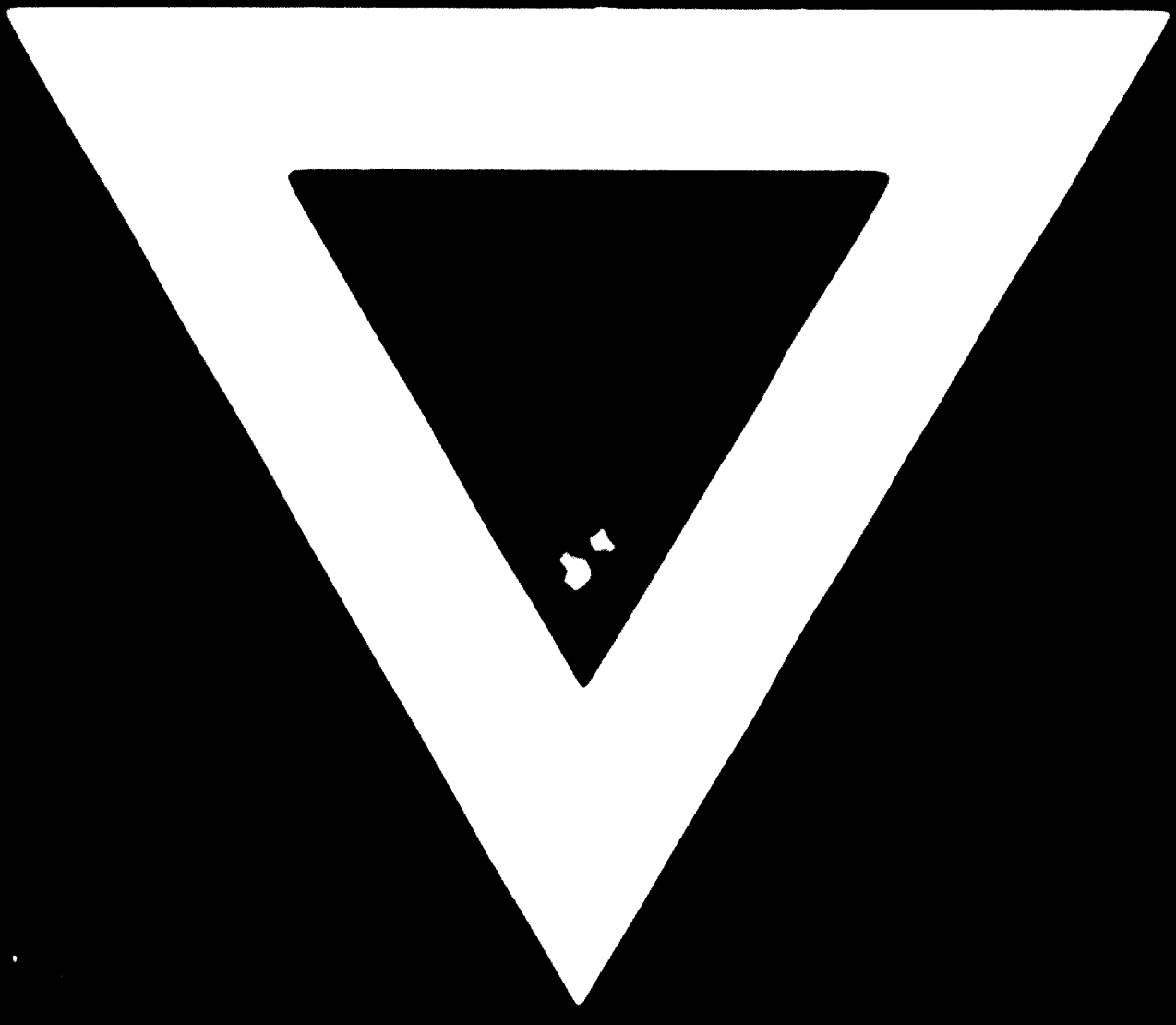
I have tried to outline what I feel are the major developments in general preparation areas over the past couple of years and inevitably I have had to leave out a number of developments in other areas.

The short time preparation developments I have outlined are being used in conjunction with traditional methods, as many textile works re-equip with equipment capable of applying these new methods.

There has been much talk of single stage processing, that is grey fabric to prepared with only one process stage and for some fabrics this is certainly possible, but it is my view that it will be some time before a single stage system is available for all fabrics.

However, what is possible for all fabrics is a continuous multi-stage preparation system which, if set up in series, will enable cloth ready for subsequent dyeing, printing or finishing to be available from grey fabric in a matter of minutes. But what is more important than the speed of the operation is that every metre of fabric prepared by this special process will be in the proper condition for use and we may at last have fulfilled the true definition of preparation.





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