Introduction

Wet Processing includes preparation (Mercerising, Scouring, Bleaching) and dyeing.

The major focus of STARFISH is on the influence that these processes exert upon the Reference Dimensions of knitted fabrics, rather than the science and technology of the processes themselves.

Knowledge about the science and technology of wet processing is readily available from standard textbooks, and from suppliers of machinery, dyes and chemicals. The following provide only a few background notes.

Scouring and Bleaching

Cotton is a natural fibre and therefore contains several impurities. Analysis shows that raw cotton typically consists of the following constituents, in percentage by dry weight (ignoring moisture, which is about 7%).

Cellulose	88	-	96
Pectins	0.7	-	1.2
Natural wax	0.4	-	1.0
Proteins	1.1	-	1.9
Inorganics (ash)	0.7	-	1.0
Other organics	0.5	-	1.0

Additionally, most cotton knitting yarns contain about 0.1 to 0.25% of paraffin wax as a knitting lubricant. The combination of the natural wax and the applied paraffin wax ensures that raw cotton fabric is normally completely water repellent and rather difficult to wet. This is the reason why it is often difficult to get the raw fabric turning in a winch-beck or jet. It is not until the fabric becomes thoroughly wet that its surface frictional coefficient increases to a high enough level so that the winch can actually move the fabric forward.

To ensure uniform application of dyestuffs it is necessary to make the fabric uniformly absorbent, to make sure all of the paraffin wax and most of the natural wax are removed (without re-deposition), and to thoroughly wet and swell all of the fibres. Failure to achieve such a state in the fabric is responsible for the majority of problems to do with non-uniform dyeing. It does not pay to cut corners in preparation. To be safe, scouring in alkali and a good detergent should be for at least 45 minutes at 90° Celsius, followed by efficient hot rinsing.

Another problem is the occasional presence in raw cotton of certain metal salts (Calcium, Magnesium, Manganese, Iron) which can interfere with bleaching and / or dyeing and which cannot be removed by alkali scouring alone. Cottons that contain these impurities require an acidic-demineralisation treatment before scouring. Many dyers apply the demineralisation treatment as a matter of course, to all cotton fabrics.

Modern bleaching systems are based, almost exclusively, on hydrogen peroxide. If reactive dyeing is to follow, it is essential to ensure that all of the peroxide is "killed", either by reduction or by enzyme systems, and that residual alkali is properly neutralised.

Dyeing

The effect of any wet process upon the Reference Dimensions of the fabric is primarily determined by three factors.

- Processing tension
- Processing time
- Energy put into the fabric, e.g. by high jet pressures and high fabric speeds

So far as possible, these variables should be standardised for each wet processing sequence, and maintained constant for a given fabric quality. Automatic process control is desirable.

In the case of the dyeing process, this means above all the achievement of a high percentage of "Right First Time" dyeings.

This subject has been intensively discussed in the technical literature and will not be repeated. The series of papers from Zeneca (now BASF/Dystar) are exemplary texts.

If the finishing processes will include Compacting, and if the lubricant is to be applied as a dyeing after-treatment, then it is important to try to achieve a uniform distribution of the lubricant over the whole length and width of the dyelot. Many lubricants applied in this way are cationics, which have relatively high substantivity (i.e. a high strike rate) for cotton. Under these conditions, it is not difficult to get a very non-uniform treatment that can lead to problems of non-uniform processing at the compactor.

Mercerising

Mercerising is the treatment of cellulosic textiles in yarn or fabric form with a concentrated solution of caustic soda (sodium hydroxide), whereby the fibres are swollen, the strength and dye affinity of the materials are increased, and their handle modified. The process is named after its discoverer John Mercer (1844). Horace Lowe (1889) discovered the additional effect of enhancing the lustre by stretching the swollen materials while wet with caustic alkali.

Where fabric mercerising is used, it is normally the first wet process but "white" mercerising is sometimes practised in order to preserve clean waste liquor, for more efficient recovery of the caustic soda. Mercerising strength caustic soda swells the fibres and permanently alters their shape to a more rounded cross-section.

The major benefits are increased lustre, a cleaner fabric surface, and a large increase in the efficiency of dyeing. Efficiency of dyeing in this context means that a given depth of shade can be obtained with a lower concentration of dyestuff in the dyebath. Printed fabrics show brighter colours and cleaner print outlines. Garments made from mercerised fabrics preserve their surface appearance better through multiple domestic launderings.

Dyeing efficiency can be increased by between 30 and 65%, depending on the type of dyeing system and the depth of shade. Colours tend to be brighter and cleaner. Some very dark shades can be achieved on mercerised fabrics that are impossible, or prohibitively expensive to obtain on unmercerised goods.

The development of lustre requires that the fabric be either restricted from shrinking during the process, or be restretched during the washing-off or stabilising section.

The most popular concentration of Caustic soda for mercerising is about 28° Baumé (22% w/w) but it can be as low as 24° Be or as high as 33° Be. Treatments in the range 18° - 22° Be are also used but these are semi-mercerising processes, carried out on simpler machinery to achieve a modest degree of increase in dyeing efficiency.

The most popular mercerising temperature is room temperature but the caustic soda solution can be refrigerated to below 15° Celsius or heated to over 60° C. Refrigeration results in greater, but slower swelling of the fibres; heating results in faster, more uniform penetration but a lower degree of swelling. At room temperature, penetration and swelling requires at least one minute, preferably two. Penetration and swelling are most efficient when the fabric is allowed to shrink (as in most tubular mercerisers), rather than when the fabric is prevented from shrinking (as in most open-width mercerisers).

The precise conditions of concentration, temperature, swelling time and amount of restretching affect the outcome significantly, so far as the Reference Dimensions are concerned. For this reason, it is important to adopt processing conditions that can easily be maintained at constant levels, and to ensure that constancy is actually maintained.

A parameter, which needs to be watched, is the amount of restretching which is applied in the stabilising zone of a tubular merceriser. In the Dornier merceriser, the amount of restretching is controlled by the diameter of the "cigar" in the stabilising zone. For a given fabric construction, increasing the diameter of the cigar changes the final Reference Width only slightly but the Reference Length is more significantly affected.

In a series of trials carried out on a (first generation) Dornier machine, the cigar diameter was varied in five increments, related to the Reference Width of the corresponding dyed, unmercerised fabric. The minimum cigar diameter was about 75% and the maximum was about 97% of the Reference Width of the dyed, unmercerised fabric. Over this range, it was found that the final Reference Widths of the series of mercerised fabrics after dyeing and finishing varied by less than one percentage point - between 86% and 87% of the corresponding unmercerised fabrics. However, the Reference Lengths of the mercerised series varied by four percentage points - between 102% and 106%. The wider the cigar, the longer and narrower the final finished fabric. In these trials, the fabric was plain jersey with a tightness factor of about 15.8. For different fabric types, and for different tightness factors the results would be different.

Similar results have been found with other types of tubular mercerising machinery.

When choosing cigar settings, it would be wise to standardise on a fixed percentage of the Reference Width of the corresponding unmercerised fabric. The ideal cigar width should first be established with regard to ease of processing and the final product performance but, once established, the ratio of cigar width to unmercerised Reference Width should be standardised and maintained for all similar qualities of the same fabric type. It is likely that the optimum ratio will be found to be in the region of 0.85 to 0.90. If the Reference width of the dyed and finished fabric is not known in advance, then the Reference Grey Width can be used as the basis.

A limitation of open width mercerising machines, which restrain the fabric from shrinking during swelling is that a different wale density is developed at the edges of the fabric, compared to the centre. The effect is most noticeable in machines, which originally were designed for mercerising woven fabrics, and have been adapted for open width processing of knits. The limitation of variations in wale density is claimed to have been overcome in the latest open width mercerising machines which have been specially designed for knits, but this claim has not been tested in the current STARFISH Database (2012).