Introduction

The Standard Wet Process and Depth of Shade options provided in STARFISH enable the average effects of different types of Wet Processing routes to be determined very rapidly. Similarly, by using the Standard Yarn Type options provided, the average effects of using different Yarn Qualities can be discovered.

The Standard STARFISH Prediction Equations have been developed from many industrial trials and represent average values for typical yarns and wet processing routes. Choosing the appropriate Standard Yarn Type, Standard Wet Process and Standard Depth of Shade options will usually provide Predictions of the Finished Fabric Properties of sufficient accuracy for the majority of situations. This is because, within yarn and process types, the differences between average and specific conditions are usually no greater than the reliability of manufacturing and testing tolerances.

Most of the time this is perfectly satisfactory; for knitters to help them to establish viable knitting specifications and for finished fabric buyers to help them to establish realistic performance specifications.

However, the dyer and finisher will often need to be more precise. This is because wet processing routes are not necessarily average (due to variations in machinery and processing practice between dyehouses) and in addition, the yarns that are being used by his knitters may not be average either (due to variations in the fibre quality or machinery used by different spinners).

If the STARFISH predictions do not correspond to actual measurements, either

1. the Knitting Quality is not exactly as specified, and / or
2. the relaxation procedure being used to measure shrinkage and Reference Dimensions does not correspond exactly to the Reference Relaxation Procedure and / or
3. the Wet Processing route does not have exactly the same characteristics as one of the Standard Wet Process and Depth of Shade options provided in STARFISH.

In the latter two cases, it will nevertheless be found that, for a given Wet Processing route (and yarn quality) over a series of measurements, the offset between the Standard STARFISH Predictions and the actual measurements tends to be constant. Over time, the values of these constants will become apparent for each of the finisher's wet processing routes. They represent calibration constants that allow the finisher to "fine tune" the Standard STARFISH Predictions to suit his own situation.

If, over time, the differences are not substantially constant, then either the process conditions are not constant or the finisher's own relaxation procedures are unreliable or the knitter is not delivering a consistent quality of cloth. In either case, this is something that the finisher needs to know about and take action to correct.

Therefore, the dyer and finisher should aim to become familiar with the STARFISH Process Calibration Procedure, and carry this out for his main processing routes and product types, and repeat the exercise from time to time to make sure that all is still under control. The influence of changes in processing will thus be identified and established. Any deviation from specification by the knitter will also be detected if regular calibration checks are made.

In addition, the Process Calibration Procedure is a valuable Quality Control Tool that enables the dyer and finisher to monitor his processing, and to identify any changes in process conditions that affect fabric stability.

Finally, the Process Calibration can be transferred to the STARFISH Software by utilising the Prediction Window: Seek Calibration to create a User Defined Process. This is especially valuable for processes that are not covered by STARFISH (e.g. Resin Finishing), or for processes that are very sensitive to the detailed machine settings and operating conditions (e.g. Mercerising).

Process Calibration

Process Calibration consists essentially in monitoring the Reference Courses and Reference Wales of one or more standard knitted qualities processed through each of the finisher's standard wet processing routes.

There are three main reasons for Process Calibration;

- Firstly, to provide a tool that can be used as a powerful aid to process control and Quality Assurance independent from the STARFISH software.
- Secondly, so that the Standard STARFISH Predictions can be adjusted to model more precisely the conditions in the mill where the fabric is being processed.
- Thirdly so that Process Calibration Ratios can be established that can be used to make predictions for Fabric (or Yarn) Types that are not covered explicitly by the STARFISH software.

After a sufficient number of measurements of the Reference Courses and Wales are available for reliable estimates of their Mean and Standard Deviation (or mean range) to be obtained, then these values can be used to

Set up Quality Control Charts for the process, to make sure that it is delivering consistent results, or to trace the sources of inconsistencies so that these can be eliminated.

Find which combination of the Standard STARFISH Wet Process and Depth of Shade options comes closest to predicting the mean values and then create a User Defined Process (UDP) that predicts exactly the measured mean values.

Process Calibration Procedure

The Process Calibration procedure consists essentially in monitoring the Reference Courses and Reference Wales of one or more standard knitted qualities processed through each of the finisher's standard Wet Processing routes.

For this procedure, it is important to select a fabric that can be relied upon for consistently uniform knitted construction, with both Yarn Quality (specifically Yarn Count) and Stitch Length under excellent control.

1. Select and sample a series of Grey Fabric rolls that will be subjected to the process that is to be calibrated.
2. Make whatever measurements are necessary on the grey fabric to confirm the actual knitted construction. If there is total confidence in the knitter (because of objective measurements carried out in the past) then no measurements may be necessary. If there is less than perfect confidence, then the Yarn Count and Stitch Length should be accurately determined.
3. Carry out the normal dyeing and finishing process.

   The severity of preparation (e.g. Scour only, half Bleach, full bleach) and the depth of shade (percentage dye in the bath based on the weight of fabric) are a part of the process definition. Different preparations and different depths of shade may yield differences in the Reference Dimensions - especially in the weight.
4. Sample the same rolls after dyeing and finishing and carry out the Reference Relaxation Procedure. Measure the Reference Course and Wale Densities. If maximum accuracy is required for the calibration (especially in the case of Mercerised or Resin finished fabrics), then measure the Reference Yarn Count, Stitch Length, and Weight per unit area.
5. Repeat this procedure several times for different deliveries of the same Knitting Quality and Wet Process to obtain good average values before making any attempt to utilise the values for Quality Control or for developing a new User Defined Process.

Notes:

- *It is advisable to repeat this procedure several times with the same or similar quality and wet process to obtain good average values before any attempt is made to utilise the values for process control or for setting up a new UDP. Single sets of test data are not sufficiently reliable. However, with a little patience, a good picture can be built up over a period without excessive workload.*
- *The Reference Course and Wale Densities, and the Reference Weight should remain more or less constant over a period of time so that they can be continually updated and refined. Data for different preparation intensities and different depths of shade should be considered separately at*

first and a conscious decision should be made whether certain sets can be combined under the heading of one average process.

- *Once the process is well characterised, then STARFISH can be customised with a named UDP, and Quality Control Charts can be set up according to the normal rules of statistical process control. Routine measurements can then be made, at a reduced level, on a regular basis and plotted on the QC chart. If they change significantly, or show a tendency to drift, then this is a good sign that something in the whole fabric-finishing-testing system is changing and requires investigating.*
- *The Wet Process Calibration Procedure must be done carefully and updated regularly. It consumes significant resources and should therefore provide commensurate benefits. This it certainly does. When a Wet Processing Route is properly calibrated, then the average Reference Dimensions can be calculated accurately using the STARFISH software, before any given fabric is ever put into work.*

Benefits of Process Calibration

There are at least three direct benefits for the dyer and finisher of developing and maintaining an accurate knowledge of the Reference Dimensions through Process Calibration.

Improved Customer Service

Once the average Reference Dimensions are accurately known a STARFISH User Defined Process can be created. This allows the finisher to

Check the demands and the specifications of his customers with complete confidence. If a specification is unreasonable, then the customer can be advised and, more importantly, can be offered an alternative specification, which is attainable.

Check that the knitting specification for a given grey cloth is in fact the correct one for delivering the required final Performance Targets after finishing.

Assuming that both the grey cloth and the customer's specification are reasonable, then

- the proper finishing Control Targets, in terms of width and course density, for any given knitted quality can be immediately determined.

Provided that these targets can actually be achieved, then

- the required combination of weight and shrinkage in the delivered fabric can be guaranteed.

Reduced Costs of Quality Control

The time and effort expended on routine Quality Control can be reduced considerably.

If the fabric is correctly knitted, and if the finishing Control Targets of width and course density have actually been achieved, then the Performance Targets of weight and shrinkage must also be correct.

Therefore, it is not necessary for the finisher to monitor weight and shrinkage routinely on the finished fabrics - only width and courses. These two are the quickest and easiest measurements that can be made and, moreover, they need to be made on a routine basis anyway in order to control the final production. Making routine measurements of weight and shrinkage is not only expensive the measurements are also very unreliable.

So far as ensuring that the Performance Targets of weight and shrinkage are met, the major effort of the quality control department should be directed towards calibrating and monitoring the process. This will yield much greater benefits than performing mindless and largely ineffective routine tests on samples taken from fabric that has probably already been packaged (or even delivered to the customer) before the QC test data have been reported.

Many practical dyers and finishers are very nervous about abandoning shrinkage testing, but experience has shown that provided the Reference Dimensions are known accurately then the calculated weight and shrinkage values are actually at least as reliable as directly measured values.

Improved Process Management and Control

Monitoring the Reference Dimensions through regular checks and the use of Quality Control Charts enables the dyer and finisher to

- establish that the process is performing consistently, or
- if a problem is discovered to quickly trace the source of inconsistencies so that they can be eliminated.

When new processing machinery is commissioned or when changes are made to existing processing routes then the effect of these changes can be quickly established so that

- the Finishing Control Targets can be adjusted, or
- customers advised that a change is required either to the Knitting Quality or to the Performance Targets,

BEFORE fabric is rejected because the delivered weight or shrinkage performance has changed.

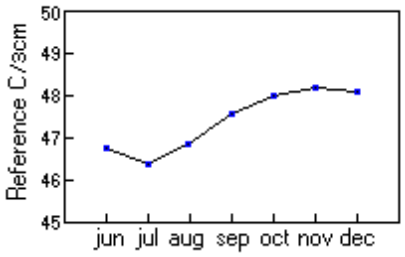
Using Process Calibration Data

Process Calibration as a Quality Assurance Tool

The value of Process Calibration as a routine quality assurance tool can be illustrated using some results taken from an industrial case study.

A vertical knitting, dyeing, finishing, and garment-making plant had experienced a change in the performance (especially length shrinkage) of garments made from a long-running, standard Plain Jersey fabric even though there had been no change in the knitted fabric specification or the delivered weight and width of the finished fabric.

Fortunately, the finishing plant had kept comprehensive quality control records, from which it was possible to calculate the Reference Dimensions for a large series of samples spreading over a period of seven months. Some results are shown in the diagram in the form of monthly averages for the number of Courses / 3 cm in the Reference State.



Clearly something happened in the month of August that affected the Reference Dimensions of this normally standard and consistent fabric quality. In fact, the problem coincided with the installation of new machinery with consequent changes in processing routes.

If this company had been monitoring and plotting the Reference Courses and Wales on Quality Control Charts, on a routine basis, then the problem would have been spotted almost immediately, so that corrective action could have been taken.

When the finisher can quantify the changes that are introduced in the Reference Dimensions as a result of his own operations, then he can have some control over the performance of the fabric he is producing at the end of his processing line. He can calculate the right Targets for Finishing, in terms of course densities and width, to ensure the required weight and stability.

It is in the interests of the dyer and finisher to know what is the likely effect of his processing on the Reference Dimensions of any fabric that he will be asked to finish. If this is not known, how can a sensible specification be agreed with the customer?

STARFISH Calibration

Process Calibration consists essentially in monitoring the Reference Courses and Reference Wales of one or more standard knitted qualities processed through each of the finisher's standard wet processing routes.

After a sufficient number of measurements of the Reference Courses and Wales are available for reliable estimates of their Mean and Standard Deviation (or mean range) to be obtained, then these values can be used to create a User Defined Process (UDP) that predicts exactly the measured mean values.

STARFISH Calibration can only be carried out for one specific Quality in the Active Model at a time. For this reason it is recommended that a new Model be created specifically for the Calibration exercise. Once an appropriate Calibration has been developed, named and saved as a User Defined Process then this process can be recalled and used with any other Model for the same Fabric Type and Yarn Type.

STARFISH Calibration is carried out using the Prediction Window Seek Calibration by making adjustments to the Standard STARFISH Calibration Ratios for Courses and Wales, and the Value for the Net Process Weight Change.

The Calibration Ratios are adjusted by altering the Standard STARFISH Predicted Values for the Reference Courses and Wales.

The Net Process Weight Change is adjusted either by altering the Standard STARFISH Predicted Values for the Reference Yarn Count and Stitch Length or by altering the Value for the Net Process Weight Change directly.

Briefly to create a STARFISH Calibration and save it as a User Defined Process.

1. Create a STARFISH Model for the Quality to be calibrated. Select an appropriate Yarn Type from one of the Standard options and use the actual knitted values for the Yarn Count and Stitch Length. Select the standard options for Wet Process and Depth of Shade that provide the closest match to the measured data.

   It is not necessary to choose the standard options that correspond by name to the actual wet process and depth of shade that has been used. These selections provide only the starting point for the calibration. A new Process Name and Shade Name can be provided once the Calibration has been developed.

2. Select the Quality and open the Prediction Window Seek Calibration.
3. Adjust the Standard STARFISH Predicted Values for the Reference Courses and Wales that are displayed in the Calibration Table until the values correspond to the actual values that have been measured.
4. If necessary, adjust the Standard STARFISH Predicted Values for either the Reference Yarn Count and Stitch Length or the Net Process Weight Change also.
5. Select the Save button to open the Save Calibration dialog box, type a Process Name in the Process Name box and a Shade Name in the Shade Name box and then select the Save button.

Note:

STARFISH Calibration should always follow Process Calibration. It can be carried out using either Reference Data or Data collected on the Finished "As Delivered" fabric. In either case, it is important to remember that Calibration should only be carried out using average data that have been derived from measurements made on a sufficient number of representative samples taken from normal production. Measurements made on a single sample will almost always give misleading results.

Calculating Process Calibration Ratios

Process Calibration Ratios can be used when the exact Fabric Type and/or Yarn Type to be processed, and/or the Wet Process to be used are not available in STARFISH but a similar Yarn or Fabric Type is.

Calibration

Process Calibration Ratios are calculated from the STARFISH predictions for Reference Courses and Wales and those that the finisher actually measures on the finished product.

The principle used is that, for a given Fabric Type, Yarn Type and Wet Process, there will be a more or less constant ratio between the Reference courses and wales measured after finishing and those predicted by STARFISH for a similar Fabric Type that is made from a different Yarn Type, or finished through a different Wet Process route. Calibration Ratios are an alternative to User Defined Processes.

Example

A manufacturer of fleece fabrics has calibrated his processing for two-thread fleece fabrics but three-thread fleece is not available in STARFISH. However, he does have Reference State data for one of the three-thread fleece fabrics. How can he use this knowledge to calculate Finishing Control Targets for a new three-thread fleece quality?

The first step is to make STARFISH predictions for the three-thread fabric as though it were two-thread fleece.

The yarn count to use for the predictions is the sum of the ground and tie yarns, and the stitch length is that of the ground yarn.

If the STARFISH predictions are Cs and Ws, and the Measured Courses and Wales are Cf and Wf, then:

Courses Calibration Ratio: CR = Cf / Cs

Wales Calibration Ratio: CR = Wf / Ws

Following are some data taken from an actual case study.

	Measured (3-thread)	Starfish (2-thread)	Calibration Ratio
Reference CPI	35.8	32.4	1.105
Reference WPI	23.0	21.9	1.050

How should another three-thread fleece fabric be finished through the same route, if STARFISH predictions for the corresponding two-thread fleece fabric are 33.3 courses per inch and 28.4 inches tubular width?

By applying the previously calculated Process Calibration Ratios to the new STARFISH predictions, it can be calculated that the Course Density Target for the new quality should be 36.8 per inch and the Finished Tubular Width should be 27 inches.

CPI	=	33.3 * 1.105	=	36.8
Width	=	28.4 / 1.050	=	27.0 inches

Note:

The predictions of fabric weight per unit area made by the STARFISH two-thread fleece model based on these calibrations will need to be adjusted slightly to find the weight of the corresponding three-thread fleece fabric. This is because the tie yarn in a three-thread fleece has a longer stitch length than the ground yarn.

To make the correction:

Look on the View Specification screen to determine the percentage weight share of the face yarn in the two-thread fleece fabric.

Determine the additional length of the tie yarn stitch length over the ground yarn stitch length in the three-thread fleece fabric.

Calculate the additional weight due to the extra length of the tie yarn.

Add this to the two-thread weight prediction.

Example

Predicted two-thread fleece weight	= 300 gsm
Predicted weight share of face yarn	= 60%
Additional length of tie yarn	= 10%
Additional weight	= 300 * 0.60 * 0.50 * 0.1 = 9
Weight of three-thread fleece	= 300 + 9 = 309 gsm

Process Weight Loss

Cotton fabrics lose weight during Scouring and Bleaching but they gain weight during dyeing and finishing. The net result is usually a loss in weight, called Process Weight Loss.

Actual measured values for Process Weight Loss can be used to Calibrate a STARFISH model when one of the standard Depth of Shade options is not sufficiently accurate.

Many dyers and finishers will weigh the incoming grey rolls and the outgoing finished rolls to establish overall average net weight losses. Others will measure the piece lengths and calculate roll weights from the fabric weight per unit area, measured on cut samples. These are simple and practical measures to use for cost control purposes but for various reasons they do not give an accurate measure of process losses. They are not suitable for use in calibrating STARFISH.

Note:

Comparisons of changes in weight per unit area from grey to finished fabric are especially unreliable in this respect.

A more accurate estimate of process losses can be obtained by comparing the weight per loop in the grey and finished fabric.

However, it is the nature of process losses that they are not constant, from time to time, from wet process to wet process, and from fabric quality to fabric quality. This means they must be handled statistically, by classifying fabrics and processes into groups and by taking more or less frequent measurements over a period of time.

Handled in this way, a relatively accurate picture can be built up for use either to reveal the true extent of unavoidable fabric weight changes (to exert pressure on avoidable losses) or to calibrate the STARFISH software.

Calculating Process Weight Loss

The method depends on the basic formula for the calculation of Fabric Weight, from Yarn Count, Stitch Length, and Stitch Density.

Wt = tex * SL * C * W * F

Where:

Wt is the fabric weight per unit area; tex is the Yarn Count; SL is the average Stitch Length; C is the true Course Density; W is the true Wale Density and F is a scaling factor, depending on the measurement units.

The formula applies equally to grey and dyed and finished fabrics, provided that the tex and stitch length of the dyed and finished fabric is used for the calculation of finished fabric weight.

In the grey fabric, we should have an accurate knowledge of the yarn count and the stitch length, because these are the knitting specification. But we do not know the stitch densities because these are not process control parameters.

In the dyed and finished fabric, we should have an accurate knowledge of the course and wale densities, because these are the Finishing Control Targets, and we can easily determine the weight per unit area. But we do not know the tex and stitch length.

Using these two sets of information, we can estimate process losses by comparing the weight per loop in the grey and finished materials.

In the grey fabric, the weight per loop is given by

LpWt (g) = grey yarn tex * knitted stitch length * F

In the finished fabric, the weight per loop is given by

LpWt (f) = Weight / C / W

And the percentage process loss is then given by

Net Weight Change % = 100 * (LpWt (g) - LpWt (f)) / LpWt (g)

All of the necessary data should be available in the QC records of a well-run operation. It is only necessary to organise the system of logging and manipulating the data to facilitate calculations of process losses as a routine part of the process control / quality assurance system.

Calculating Process Weight Loss Example

The following data are taken from an actual industrial case study on Plain Jersey fabric, dyed to three different colours in deep shades.

Grey fabric	Nominal	Measured
Yarn Count, Ne	30	29.8
Stitch length, cm	0.282	0.2819

Finished Fabric	Yellow	Navy	Red	Average
Courses, cm	19.0	19.77	18.6	19.13
Wales, cm	15.0	15.0	14.9	14.97
Weight, gm²	153.5	160.5	154.3	156.1

Calculations

1.	Grey yarn tex	=	590.5 / 29.8	=	19.82
2.	Scaling factor	=	0.1		
3.	Grey weight per loop	=	19.82 * 0.2819 * 0.1	=	0.5587
4.	Finished weight per loop	=	156.1 / 19.13 / 14.97	=	0.5451
5.	Net Process Weight Loss %	=	100 (0.5587 - 0.5451) / 0.5587	=	2.43

It should be emphasised that the result is quite sensitive to the accuracy of individual measurements. At least ten independent determinations are required for a reliable average.