About STARFISH
Basic Technological Concepts

The STARFISH prediction system is founded on the following basic technological concepts.

The fundamental structural unit of a knitted fabric is the loop. Any circular knitted fabric is composed of row after row of interlaced loops. Different types of fabric are made by different methods of interlacing the loops. Therefore, the gross dimensions of any knitted fabric are simply a reflection of the average shape and size of the individual loops, summed over the total number of loops in a given area of fabric.

There are four major sets of production variables that affect the average shape and size of the loops. These are:

1. Knitting Variables

So far as the average dimensions of the loop are concerned, the most important knitting variables are:

- **The type and size of the yarn**

  The type of yarn (ring, rotor, carded, combed) and its Twist Liveliness govern the general shape of the loop (relative height and width). The size of the yarn (Yarn Count) determines the weight of each loop and its thickness.

- **The average length of yarn in each loop**

  The average length of yarn in the loop (Stitch Length) determines the weight of the loop and also the overall size of the loop (number of loops per unit area).

Furthermore, the size of the knitting machine (number of needles) determines the number of loops across the width of the fabric, and hence the fabric width.

2. Wet Processing Variables

The effect of Wet Processing is to:

- **Change the weight of the yarn**

  The yarn weight is changed due to the removal of impurities and the addition of chemicals, such as dyestuffs and lubricants.

- **Change the average length of yarn in each loop**

  The average length of the Loop is changed through yarn shrinkage.

- **Change the shape of each loop**

  The Shape of the Loop is altered mainly because of changes to the bulk and the Twist Liveliness of the yarn.

Different types of Wet Process change the weight, length, and shape of the loops by different amounts.

3. Stretching During Processing

During Knitting, Wet Processing, and other handling operations, the fabric is subjected to tensions of varying degrees in both length and width directions. The amount of stretching or contraction suffered by the fabric, at different stages, depends on the particular procedures used.

These changes in gross fabric dimensions alter the length, the width, and the weight per unit area of the fabric and cause corresponding changes in the average Shape of the Loops.

A fabric that has been pulled out in the length and allowed to contract in the width will contain very elongated loops, i.e. loops with a high ratio of height to width (low Course / Wale Ratio). It will consequently exhibit a high degree of length shrinkage.

4. Relaxation Treatments

A fabric that has been stretched during processing and handling contains potential energy that can be released during a wet relaxation treatment - such as home laundering - aided by swelling of the yarns.

Shrinkage of cotton knitted garments is simply the relaxation of strains that have been imposed during manufacture. Some relaxation treatments are more effective at relieving strains than others.

Basic Technological Concepts

The most effective relaxation treatment is a vigorous (tension-free) wash followed by (tension-free) Tumble Drying.

Therefore, in order to deliver a fabric with guaranteed low levels of shrinkage, a manufacturer must know what will be the dimensions of that fabric after it has been shrunk to its maximum extent. When the fully relaxed dimensions of a given fabric are known, then it is relatively easy to calculate the dimensions that must be delivered to the garment maker, in order to guarantee a certain maximum level of potential shrinkage during home laundering.

The problem lies in defining exactly what is meant by "after shrinking" since different methods of testing for shrinkage will give different answers on the same fabric.

The most obvious example is that when a Tumble Dryer is used as part of the test method, then the level of shrinkage recorded will be greater - sometimes much greater - than when a tumble dryer is not used.

In the case of a particular customer, obviously "after shrinking" means "according to the test method that the customer uses himself". But most manufacturers have more than one customer and these customers will not all use the same test methods. In addition, if the final shrinkage performance is to be **guaranteed**, then it is necessary to consider what will be the largest possible shrinkage that the fabric will ever experience in the hands of the ultimate consumer.

One thing that is certain is that, in order to be able to develop a system for predicting the dimensions of fabrics after shrinking, the shrinkage test to be used has to be very reliable and reproducible. It also should be one that will induce the maximum possible amount of shrinkage in a given fabric so that all different types of laundering conditions can be allowed for.

Throughout the development of STARFISH very extensive studies of the shrinkage behaviour of cotton knits have been carried out. From the results of this research it was concluded that the most representative and the most reproducible method of test was one that includes multiple cycles of machine washing and tumble drying.

Therefore, a Reference Relaxation Procedure was defined that comprises five cycles of machine washing and tumble-drying. A sample of fabric that has been subjected to this Reference Relaxation Procedure is said to be in its **Reference State (of Relaxation)**.

The STARFISH Reference Relaxation Procedure is defined as follows: -

1. Wash in automatic machine at 60°C, standard detergent, no softener.
2. Tumble dry to constant weight.
3. Wet-out in automatic washing machine (rinse cycle).
4. Tumble dry to constant weight.
5. Repeat steps 3 and 4 three more times (total five cycles).
6. Condition to normal regain.

About STARFISH

STARFISH Technology

STARFISH Technology is an integrated system of Product Engineering, Quality Assurance, and Application Know-how that can be applied to upgrade the performance of cotton circular knitted fabrics. It is a total manufacturing concept that provides a practical and cost-effective system for the production of cotton knitgoods.

The name STARFISH is contracted from the phrase "START as you mean to FINISH". It embodies the principle that, in order to know how to produce a knitted fabric with the desired dimensions and performance, it is first necessary to have an accurate knowledge of the final finished product.

In other words, it must be possible to predict what will be the dimensions and performance (weight, width, shrinkage) of any proposed fabric quality after dyeing and finishing, even though that particular quality has never been made before.

It comprises three main elements:

1. **Product Engineering**

   The STARFISH Prediction Software enables accurate and reliable information about the dimensions and performance of the dyed and finished "as delivered" knitted fabric to be obtained prior to fabric production and processing.

   This allows customer requirements to be evaluated before committing expensive resources on trial and error sampling, and provides the tool by which the fabric can be engineered to meet a given performance specification.

   Using STARFISH, the time required to develop appropriate knitting and finishing production specifications for each new fabric quality is reduced significantly thus allowing the product development process to be carried out as rapidly and as cost effectively as possible.

2. **Quality Assurance**

   The production of cotton knitgoods with the Properties demanded by the modern consumer requires the implementation of appropriate Quality Assurance Systems. In addition, close attention to Quality Control procedures throughout the entire manufacturing operation is essential to ensure that production specifications once established are met consistently.

   The STARFISH Prediction Software enables the most important variables in the production and processing of the knitted fabric to be identified and their effects on the properties of the finished fabric to be calculated. This allows the quality control function to be effectively targeted at the most important points in the manufacturing process.

   By identifying and effectively targeting the key production variables radical improvements in product consistency can be obtained. Furthermore, by eliminating unnecessary testing in areas that have little or no direct influence on the final product dimensions and performance, opportunities exist for significant savings in the cost of the quality control function.

3. **Application Know-how**

   The STARFISH Research Project is the foundation upon which STARFISH Technology has been built. The large number of commercial scale trials that have been carried out, the thousands of fabrics that have been tested and the hundreds of thousands of individual data items that have been analysed have generated an enormous quantity of practical information on the production, processing, and evaluation of cotton knitgoods. This has enabled the fundamental reasons why cotton fabrics shrink to be deduced, the key production and processing variables to be identified, and the effect of these variables on the Properties of the finished fabric to be enumerated.

   STARFISH Training Workshops provide the theoretical background and practical application know-how necessary to speed the introduction and implementation of STARFISH Technology in the mill. These Workshops also provide practical information and guidance on the most appropriate processing technology and how to use it in order to meet the specification and achieve the targets in practice, so that fabrics of the appropriate quality can be produced consistently.

   Some of this previously unpublished information was included for the first time in the on-line help system that was developed specifically for the STARFISH 6.0 software. For Version 6.5 this reference section has been fully revised and updated.

About STARFISH
STARFISH Prediction Software

The STARFISH Prediction Software is a unique fabric-engineering tool for circular weft knitted fabrics produced from 100% cotton yarn.

In effect, STARFISH is a simulator. It models the key elements in the production and processing of circular knitted cotton fabrics and calculates their effect on the final Properties of the finished fabric. This means that in the space of a few minutes, it is possible to discover the most appropriate combination of Yarn Count, Stitch Length and knitting machine necessary to deliver the desired combination of properties in the finished fabric without expending valuable production time and materials.

Furthermore, STARFISH is the only knitted fabric engineering system that automatically takes account of the fundamental influence of both the fabric production and the wet processing and finishing operations on the properties of the finished fabric. Thus, allowing both knitting and finishing specifications to be developed with confidence.

Database

The current version of STARFISH has been developed from a database containing dimensional data, production and processing information for more than 5,000 different Fabric Qualities, manufactured and processed on commercial scale in knitting, dyeing and finishing plants throughout the world.

These fabrics have been obtained through in-house and collaborative research and technical development programs with organisations and manufacturing facilities in Africa, Asia, Europe, South America and the USA.

The database continues to expand both in the range and the number of different fabric qualities that have been evaluated. This new information will be included in future upgrades to further increase both the scope and the flexibility of the STARFISH Prediction System.

Validation

As the database continues to expand, and new and more powerful prediction equations and algorithms are developed, evaluation and testing of the output is carried out through commercial case studies and by using actual production quality control data provided by our industry co-operators.

These validation trials not only prove the accuracy of the predictions but also provide important information on the normal range of variation that can be expected in samples taken from commercial production.

Accuracy

The finished Fabric Properties predicted by the STARFISH software are average values that have been derived from the measurement of many similarly manufactured and processed circular knitted cotton fabrics. They are calculated from the exact values of Yarn Count and Fabric Tightness specified, on the assumption that the particular values entered as Finishing Targets are achievable and will be met.

The apparent accuracy with which STARFISH can predict finished fabric properties therefore depends on the accuracy of the information entered and also the reliability of the testing procedures used to determine the actual fabric properties with which the predictions are compared. If the values for yarn count and fabric Tightness entered are incorrect, or if inappropriate or unreliable testing procedures are used for evaluation then the correspondence between STARFISH predictions and measured values may not be as expected.

In validation trials, that have compared the results obtained on commercially produced fabrics sampled in various mills throughout the world, STARFISH predictions have proved to be accurate within the limitations of normal commercial variations and the accuracy of available instrumentation and testing procedures.

When five or more yarn and fabric samples are taken at random from normal commercial production within a mill, then the average fabric properties calculated by STARFISH are usually within ± 1 Standard Deviation of the Mean Value obtained from actual measurements. If fewer than 5 samples are measured then the average values predicted by STARFISH may be up to ± 2 standard deviations away from the measured mean.

About STARFISH

STARFISH Research Project

The question of how to improve the reliability and the performance of cotton knitgoods - particularly in respect of shrinkage during laundering - was the driving force behind the research that led to the development of the STARFISH Prediction Software and the concept of STARFISH Technology.

The STARFISH Research Project was originally conceived by Allan Heap while he was Deputy Director of the Technical Research Division of the International Institute for Cotton (IIC). It was instigated as a direct response to requests from the industry for help to overcome the problem of shrinkage in knitted cotton fabrics.

The project began in 1978 with a large systematic study of 20 gauge Interlock and 14 gauge 1x1 Rib fabrics produced and processed on commercial scale within the industry. A range of different Yarn Counts, Stitch Lengths and Wet Processing routes was investigated.

Three key results emerged from this early study.

- First, it was found that the relaxed dimensions of bleached or dyed and finished fabrics, measured after multiple cycles of washing and tumble drying, were significantly different from those that had been measured in the original grey fabrics after a similar relaxation treatment.
- Second, it was found that different wet processing routes changed these Reference Dimensions by different amounts.
- Third, it was found that, contrary to the most popular theories of knitted fabric geometry, the average length of the individual knitted loops was not the only factor that determined relaxed dimensions.

As a result of this study, it became clear that the K Factor theory of knitted fabric geometry is an inadequate model since it takes no account of the influence of the yarn properties nor of the effect of the fabric preparation, dyeing and finishing operations.

Further analysis resulted in the development of more sophisticated prediction equations that allowed for the effect of these major production variables to be taken into account. The new equations were built into a first prototype computer program, for in-house use, during 1980.

Over the next eight years expansion and validation of the database continued. Fabrics studied included Plain Single Jersey, fine gauge interlock and fine gauge 1x1 rib constructions. These were processed through a wider range of dyeing and finishing routes, including Mercerising and Crosslinking (resin finishing). Data analysis and software development also continued until, after extensive evaluation and industry validation trials, the first commercial version of STARFISH, Version 4.0 for MS-DOS, was released in 1988.

Following the demise of the IIC's Technical Research Division in 1990, Allan Heap and Jill Stevens set up Cotton Technology International (CTI) to continue the development of STARFISH and also to provide technical consultancy and training to the cotton textile industry world-wide.

Cotton Technology International is continuing the data acquisition and validation, background research, analysis and software development necessary to widen and improve the scope and versatility of the STARFISH software.

Version 5.0 for MS-DOS was released by CTI in 1992. It included two additional fabric types, Single Crosstuck and Double Crosstuck (piqué) fabrics, and a wider range of Yarn Qualities. It also featured enhanced facilities for taking account of the effect of different preparation, dyeing and finishing procedures by the provision of a calibration facility.

Since 1992 further expansion of the database has enabled the inclusion of two more fabric constructions, Six-thread Crosstuck and Two-thread Fleece, and the extension of the four basic yarn type options to all of the fabric types supported. In addition, further expansion of the Wet Process and Depth of Shade options, and the development of a new Calibration facility that also allows the Net Weight Change % in processing to be calculated, has greatly increased the power and flexibility of the software. These, together with many other new features, were incorporated in Version 6.0 for Windows, which was released at the end of 1997. STARFISH 6.0 was a 16 bit program designed primarily for Windows 3.1.

The last commercial version was STARFISH 6.5, which was originally released in 2002 and was a full 32 bit program. STARFISH 6.5 Version 1.04 for Windows 7 was released in 2011. STARFISH 6.5 included a new fabric type, 2x2 Rib, a new data export facility, a new tightness factor units option, new and improved screen layouts and incorporated upgrades and enhancements to many of the new features originally introduced in Version 6.0.