YARN-ENGINEERING BASED ON THE SIMULATION OF KNITTED FABRICS - INNOVATIVE CHANCES FOR THE ENGINEERING OF BLENDED YARNS -

M. Gerig and B. Wulfhorst
Institut für Textiltechnik (ITA)
Rheinisch Westfälische Technische Hochschule (RWTH)
Aachen, Germany

Abstract

Differences in yarn structure influence the properties and the characteristics of fabrics produced from these yarns. Therefore the securing and controlling of quality in spinning mills aims at providing the basis for a yarn production process that takes the final article into consideration. A fundamental support for the engineering of blended cotton yarns is the possibility to simulate knitted and woven fabrics, taking the yarn characteristics as a starting point.

The yarn evenness is the dimension with the most influence on the appearance of textiles, especially on that of knitted fabrics. It can be measured capacitively as well as optically. Both these industrially used measuring methods can be applied online and offline. They were the basis for the development of different simulation systems have consequently been put into industrial practice.

All simulation systems do not yet provide a quantitative or qualitative evaluation of the optics of simulated knitted fabrics. The new ITAOPT System which has been evolved at the Institut für Textiltechnik der RWTH Aachen (ITA) allows, for the first time, an objective final evaluation deciding on quality. Thus it provides experts with a tool to make comparing judgements more objective and independent of external influences.

This substitution of subjective, visual judgment of the optics of simulated knitted fabrics with the newly developed objective, qualitative and quantitative analysis realized by the ITAOPT System opens up new economic perspectives for the yarn-engineering, especially of blended cotton-yarns that focus on the final article.

Introduction

Especially for spun yarns that consist of fiber-blends such as for example cotton and man-made fibers, it is desirable to achieve an even distribution of the components across the yarn cross section. A homogeneous distribution of the single fiber components across the cross-section of the yarn has a positive influence on the structural parameters as well as on the dyeing and wearing properties.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:805-809 (1998)
National Cotton Council, Memphis TN

For the OE-rotor-spinning, particularly varying fiber characteristics such as the rigidity of the fibers have an influence on the tying in behavior of the fibers into the yarn. Therefore they can lead to a more uneven fiber distribution along the cross-section of the yarn which has a negative effect on the appearance of knitted fabrics. Fiber-blends that are supposed for manufacturing should therefore be coordinated with respect to their characteristics so that the final article can be specifically designed, starting from the choice of suitable fibers.

Simulation of Knitted Fabrics

The yarn feature that has the most influence on the appearance of especially knitted fabrics is the yarn evenness. It is decisively affected by the fiber characteristics of the single blend components. The yarn evenness can be measured capacitively and optically. Proceeding from these two measuring methods that are both used industrially - either on-line or off-line - the following three independent simulation programs have been developed and made accessible for industrial use (Fig. 1).

When simulating knitted fabrics with the USTER®EXPERT System it is the evenness of mass that is evaluated, while the simulation with the CYROS®System, respectively the OASYS®System, evaluates the evenness of the optically efficient yarn diameter. With all three systems it is possible to simulate various textile surfaces such as knitted and woven fabrics with varying constructions as well as yarn boards.

USTER®EXPERT System

The USTER®EXPERT System provides the means for the electronic generation of yarn boards and knitted and woven fabrics with given machine parameters, using the measuring values delivered by the USTER-Tester 3. This system aims at the visualizing of yarn defects in knitted and woven fabrics.

The system supplies a monitor display of the simulated yarn boards and fabrics which can be printed out. The evaluation of the appearance of fabrics is not yet possible. Now as before the subsequent judging of the simulated yarnboards and the knitted and woven fabrics is performed in the same way as the judging of the veritable surfaces: it is performed visually and therefore subjectively by experts.

CYROS®System

The simulation with the CYROS®System (**C**otton **Y**arn **R**ating through **O**nline **S**imulation) that is offered by CiS is based on the optically efficient yarn evenness that is measured with the yarn structure tester G580 from Zweigle.

The yarn diameter values are transformed into a three-dimensional presentation of the yarn surface. Like the EXPERT System, the CYROS System offers a monitor display of the simulations, which can be printed out. The judging of the simulated surfaces is again carried out visually by a selected circle of experts.

OASYS®System

The simulation with the OASYS®System that is offered by Zweigle, is based, similar to that of the CYROS System, on the optically efficient yarn evenness, which is measured with the yarn structure tester G580 respectively G585 from Zweigle.

The OASYS System delivers, just as the EXPERT System and the CYROS System, monitor displays of the simulations which can subsequently be printed out. The comparing judgement of the simulated displays is also performed visually and therefore subjectively by a selected circle of experts.

Comparison of Simulated and Real Knitted Fabrics

The following example will enlighten the possibilities that are given with the simulation of the appearance of knitted fabrics from various rotor-spun blended yarns which consist of PES and Cotton (50/50 %). The objective judging of such simulations with the ITAOPT System will be shown exemplarily by means of two different yarns. The two yarns differ through the choice of the fineness of the fiber components. Therefore the blend ratio related to the number of fibers is different. The yarn F/G(63/37) was produced from a fine PES (number related: 63 %) and a coarser cotton (number-related: 37 %). The yarn G/F(50/50) was produced from a coarse PES (number-related: 50 %) and a fine cotton (number-related: 50 %) (Fig. 2).

Both batches were spun into knitting yarns under the same conditions and then processed into single-jersey knitted fabrics. The gray knitted fabrics were then dyed and finished. The blue dye that was used has only affinity to cotton and does not dye the PES-fibers (differential dyeing).

The evenness of the two yarns F/G(63/37) and G/F(50/50) deviates especially as far as the yarn mass is concerned. The unevenness of the yarn diameters, however, is not as obvious. It is therefore to be expected that the differentiation of the two yarns, with regard to the appearance of the fabrics made from them, can be realized with the EXPERT System because this system is based on the evenness of the yarn mass. Nevertheless, the specific structure of OE-rotor-yarns suggests that the distinct appearance of the two fabrics can also be simulated by means of the optically efficient yarn diameter, that is to say by means of the CYROS and the OASYS Systems.

When regarding the appearance of the simulated knitted fabrics it is essential to notice that the representation corresponds to the undyed, raw-white fabric knitted from these two yarns. In contrast to this, the real fabric is colored with differential dyeing. Therefore the appearance of the real and the simulated fabric is only conditionally comparable.

It is striking that all the simulated fabrics do differ from each other, even those that are based on the evaluation of the optically efficient yarn diameter. The simulated fabrics show the same features as the genuine, dyed fabrics. The simulated knitted fabric made from F/G(63/37) is altogether more homogeneous than that made from G/F(50/50). It is also brighter and even the subjective judging reveals that the bright areas are more wale-oriented and smaller than those of the simulated fabric made from G/F(50/50). The fabric knitted from F/G(63/37) exposes a constant unevenness which affects the appearance less than the more course-oriented distribution of the very contrastive bright and dark areas of the simulated fabric knitted from G/F(50/50).

Objective Evaluation of the Appearance

So far, all three systems do not deliver the possibility to judge the appearance of the simulated knitted fabrics quantitatively or qualitatively. The judgement of the appearance of simulated fabrics which has still has to be carried out subjectively entails the same difficulties as the subjective, visual judgement of the appearance of real fabrics. The latter one, however, can already be replaced by the optical analysis of the appearance with the aid of the ITAOPT System, which has been developed at the ITA and which has been represented at the Beltwide Cotton Conference in 1996. Only since recently the ITAOPT System can also be used for an objective final evaluation that decides on the quality of simulated knitted fabrics. By this means the experts can be equipped with a new tool which will help to turn the judgement more objective and independent from external influences.

This substitution of the subjective judgement of the yarn appearance of the simulated knitted fabrics with an objective, qualitative and quantitative analysis of the appearance of the simulated knitted fabrics can be realized irrespective of the physical principle, on which the structure analysis of the yarn is based.

The simulated knitted fabrics and the digitized images of the real fabrics (REAL) are represented for all three systems as gray value images, consisting of values between 0 for black and 255 for white.

The differences in brightness that are visible both in the simulated as well as in the real knitted fabric are allocated to various gray value levels by means of the digitized original image. These gray values are allocated to one of three relative classes. The three gray value classes contain, according to their brightness the gray values of the bright, respectively dark „clouds“ and of the areas that are in between, that is to say the „standard areas“.

The allocation of every single measuring point to one of the three gray value classes, leads to a representation of the knitted fabric which is composed of only three gray values, that is white, gray and black. Bright clouds are represented as white areas, dark clouds are represented as black areas and the remaining part of the knitted surface is represented as gray area. The bright and dark areas which have thus been isolated, are subsequently evaluated with regard to their characteristics. In Fig. 3 the transformation of the appearance of the surface into a digitized image and the subsequent isolation of the „clouds“ is illustrated. For this exemplified representation the genuine knitted fabric has been used.

Evaluation of the Standardized Gray-Values

The mean graded gray values characterize the overall brightness and the standardized gray values characterize the resulting contrast between the the graded values of the knitted fabric examined. The higher contrast between the bright respectively dark areas and the standard areas in the real and the simulated fabric knitted from G/F(50/50) reveals that areas within the fabric, which are significantly darker or brighter than the mean gray value, are rare, but all the more striking. The more contrastive bright and dark areas become optically more prominent (Fig. 4).

The fact, that the difference between the bright areas and the standard areas is the smallest in both the real and the simulated fabrics knitted from F/G(63/37), proves that these fabrics are not only altogether brighter, but also more homogeneous than the fabrics knitted or simulated from G/F(50/50).

For both knitted fabrics it is obvious that the standardized gray-values of the fabrics simulated with the EXPERT System are quantitatively comparable to the genuine fabrics. In opposite to this, the contrast is more salient for the fabrics simulated with the CYROS System and the OASYS System. This higher contrast is due to the divergent representation of the simulated knitted fabrics. Through the choice of an optimized background design, this contrast can be reduced, so that it is no longer limited to qualitative comparability, but can also be consulted for quantitatively statements. Thus the propositional power of the overall representation of the simulations can be increased.

Evaluation of the Variation of the Standardized Gray-Values

The visual evenness of the appearance of various knitted fabrics is depicted by the distribution of the graded gray-values. Similarly it is in particular the standardized coefficient of variation of the gray values that is suited for a qualitative statement. The higher evenness of the distribution of gray-values of the fabric knitted from F/G(63/37) appears especially when comparing the coefficient of variation of the distribution of gray-values of the bright respectively dark and the standard areas.

For Fig. 5 a standardized representation of the coefficient of variation of the graded gray-values has been chosen. Apart from the fact that both the real and the simulated fabric knitted from G/F(50/50) are altogether darker, they are also more contrastive. By choosing a standardized representation, it becomes obvious that the higher contrast is distributed similar to the more homogeneous and brighter fabrics knitted and simulated from F/G(63/37).

The comparison of the standardized coefficient of variation confirms the suitability of the CYROS System and the OASYS System for the simulation of knitted fabrics made from OE-rotor-yarns, although they differ only minimally in their structural parameters. For the special application of the simulation of knitted fabrics from OE-rotor-spun blended yarns the EXPERT System is also suitable. Differences can be simulated realistically, that is to say the appearance of knitted fabrics can be predicted in a realistic way.

Summary

The different yarn structure of the two yarns F/G(63/37) and G/F(50/50), which is caused by the composition of the fiber-blends, is mirrored much more obviously in the evenness of the yarn mass than in the evenness of the visible yarn diameter. Nevertheless it is possible to simulate realistic knitted fabrics from OE-rotor-yarns in using the simulation based on the optically efficient yarn diameter. The reason therefore is the specific structure of OE-rotor-yarns.

The investigations, that have been represented here by examples, show that a realistic simulation of the appearance of knitted fabrics is possible on the base of the evenness of the yarn diameter as well as on the base of the evenness of the yarn mass. All three simulations can profitably be applied as prediction devices for the industrial use and for research or developmental purposes. The USTER EXPERT System, which is used for the simulation of the appearance of knitwear, differs from the OASYS System and the CYROS System with regard to the structural attributes that are measured.

For the EXPERT System it can be Stated:

The simulation of the appearance of fabrics with the EXPERT System, which is based on the evenness of the yarn mass is suited for those OE-rotor-yarns that differ in their composition with regard to the fiber fineness and the number of fibers across the cross-section. With the aid of the simulation it is possible to emphasize the more homogeneous and the brighter appearance of the fabric knitted from F/G(63/37) as opposed to the fabric knitted from G/F(50 /50).

For the CYROS System and the OASYS System it can be stated:

The simulation of the appearance of various OE-rotor-yarns from varying fiber-blends is possible on the base of the optically efficient yarn diameter. Both Systems takes even those differences into consideration, that have only a small influence on the values of the yarn structure, but a considerable influence on the appearance of the fabric.

Final Conclusions

Hitherto the simulation of the appearance of knitted fabrics was used exclusively for the off-line measurement of the evenness of either yarn mass or visible yarn diameter. This measuring device was only used for yarns that were actually manufactured on production facilities. It is, however, also possible to apply it for an on-line measurement of the yarn evenness, which enables the simulation of the knitted fabric and can thus be used for quality control. Another application could be the prediction of the quality which is to be expected under given spinning conditions. Optical and capacitive sensors for the on-line control of the yarn quality are offered by various companies.

Very interesting for this use is the optical sensor Corolab®, offered by Barco. This sensor is on one hand already approved industrially as a yarn clearer at OE-rotor-spinning machines, on the other hand it is applied for the yarn structure tester G580 and G585 from Zweigle, that is to say: it serves as a sensor for the simulations with the OASYS System and the CYROS System. The integration of the simulation systems into the production sector therefore seems realistic. Furthermore it is imaginable to connect the sensor with the spinning unit of the QUICKSPINN-System that is offered by Zellweger Uster. Thus it would be possible to predict - on the base of the optically efficient diameter - the probable appearance of knitted fabrics at a stage where the fiber components of the yarns are not even yet determined.

The values that are provided for example by Corolab, can be used just as before as basic values for the simulations CYROS and OASYS and the subsequent objective analysis based on the selection algorithms of the ITAOPT System. In this way decisions on optimum fiber-blends can be made quicker and more economically. This expanded range of uses of the simulation systems in combination with the objective and reproducible evaluation of the simulated knitted fabrics with the ITAOPT System opens up new perspectives for the fiber to yarn to fabric engineering.

Acknowledgements

We give special thanks to Gaby Peters and Chris Färber at Zellweger Uster (CH) as well as to Claus Müller at CiS Graphik & Bildverarbeitung (D) just as to Dieter Zweigle and Herbert Krupp at Zweigle Textilprüfmaschinen (D) for data processing necessary to development of this manuscript.

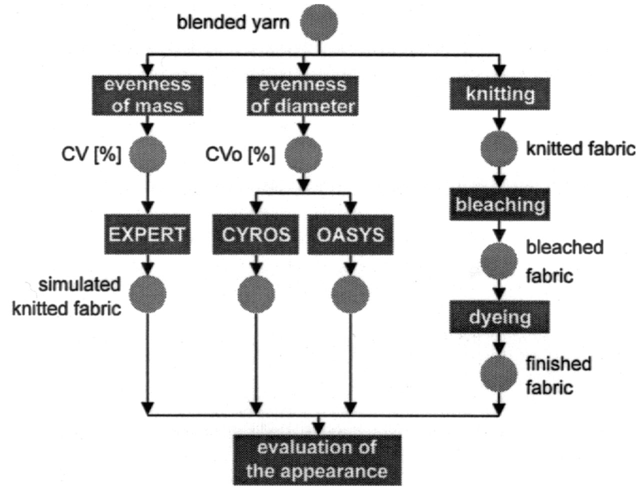

Figure 1. Engineering of knitted fabrics

		fineness of fibers [dtex]	length of fibers [mm] 50 % Sp.l. [mm]	number of fibers
PES	F/G(63/37)	1.11	25.4	91
	G/F(50/50)	1.56	25.4	64
CO	F/G(63/37)	1.92	13.3	52
	G/F(50/50)	1.57	13.2	64

Figure 2. Properties of fibers

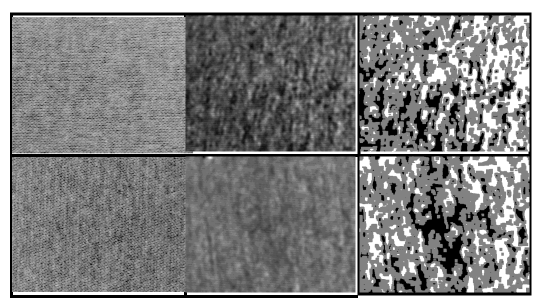

Figure 3. Evaluation of the appearance of knitted fabrics

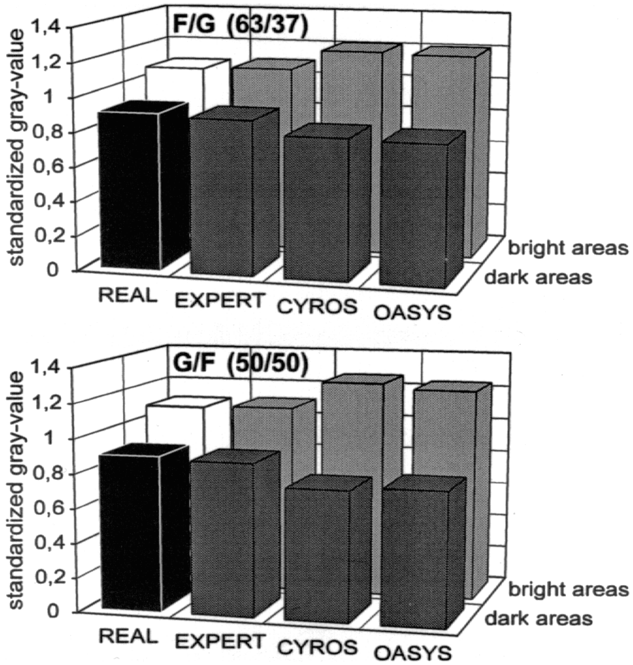

Figure 4. Standardized gray-value

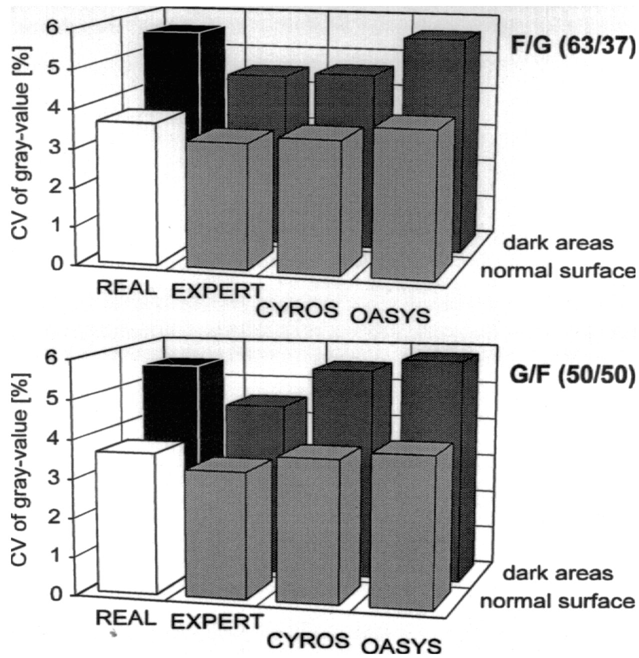

Figure 5. Coefficient of variation of standardized gray-value