YARN ENGINEERING BASED ON THE SIMULATION OF KNITTED FABRICS - POSSIBILITIES AND LIMITS FOR RING-YARNS AND OE-ROTOR-YARNS

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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 from fiber to fabric 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 two simulation systems have consequently been put into industrial practice.

Both systems do not yet provide a quantitative or qualitative evaluation of the optics of simulated knitted fabrics. The new system ITAOPT 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.

Introduction

Differences within the yarn structure have an influence on the properties and on the character of the textile surfaces that are manufactured from these yarns. Therefore the assurance of quality and the surveillance of quality in the spinning mills aim at providing the base for the production of yarns that meet all the requirements of the final product. The possibilities of the simulation of knitwear from ring-yarns and OE-rotor-yarns are fundamental for the economic development of a yarn that provides all the characteristics that are needed for the final product. Furthermore the simulation of knitwear allows a continuous and successful expansion of the range of uses for OE-rotor-yarns as compared to ring-yarns.

Simulation of Knitted Fabrics

The yarn feature that has the most influence on the appearance of especially knitwear is the yarn evenness. 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 two 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 evaluates the evenness of the optically efficient yarn diameter. With both systems it is possible to simulate various textile surfaces such as knitted and woven fabrics with varying construction as well as yarn boards.

USTER®EXPERT System

In the beginning, the USTER®EXPERT System was designed for the automatic control of measuring values, for the logging of data and for the simplification of the search for the causes of yarn defects. It made use of the measuring values that were provided by the USTER-Tester 3, the Tensorapid, the Tensojet and the Autosorter. Apart from the data transfer between the measuring equipment and the PC it is also possible to feed in additional values. The erstwhile version provided already the option for an electronic generation of yarn boards, using the measuring values delivered by the USTER Tester 3. Meanwhile the evaluation catalogue of the system has been expanded by the possibility of the electronic generation of knitted and woven fabrics with given machine parameters.

The system supplies a monitor display of the simulated yarn boards and fabrics which can be printed out. The quantitative evaluation of the appearance of fabrics is not yet possible. Now as before the subsequent judging of the simulated yarn boards 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**n-line **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.

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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 spun yarns. The objective judging of such simulations with the ITAOPT System will be shown exemplarily by means of three different spun yarns. All the yarns were made from 100% cotton and have a yarn fineness of 20 tex. The combed ring-yarn and one of the OE-rotor-yarns were made from the same fibers which had a fiber fineness of 4.3 Mic. The other OE-rotor-yarn was manufactured under the same conditions from other fibers which had a fineness of 4.6 Mic. Considering the boundary conditions, the simulated single-jersey knitwear corresponds with the actual knitwear.

The simulated fabrics generated by the CYROS System and the EXPERT System are displayed by means of gray values ranging from 0 (which corresponds to black) to 255 (which corresponds to white). This is also the case for the digitized pictures of the real knitted fabric (REAL) (Fig. 2).

Comparison of the Fabrics Knitted from Ring-Yarn

The simulation of the ring-yarn fabric, which is based on the evenness of the yarn mass (EXPERT System), shows the typical barryness, that is to say, the course-oriented „cloudiness“. The appearance is altogether more homogeneous and brighter than the simulations of the OE-rotor-yarns generated by the same system and thus clearly stands out against these fabrics.

As for the simulation of the ring-yarn fabric, which is based upon the evenness of the diameter (CYROS System), the characteristic feature of barryness that actually occurs with genuine knitted fabrics made from ring-yarn can not be made out as distinctly as for the EXPERT System. Although the appearance of the simulated ring-yarn fabric is more homogeneous than that of the simulated OE-rotor-yarn fabrics. It is not possible to definitely identify the appearance as a fabric made from ring-yarn.

Comparison of the Fabrics Knitted from OE-Rotor-Yarns

The subjective estimation of the real knitted fabric shows that, judging from appearance, the OE-rotor-yarn fabric with a micronaire of 4.6 is worse than the one with a micronaire of 4.3. These visual differences, however, are not reflected by the variation of the yarn mass. With the EXPERT System the little differences in yarn mass therefore lead to a similar appearance of the two simulated knitted fabrics. On the contrary, the simulated OE-rotor-yarn fabrics which are based on the evaluation of the evenness of the yarn diameter (CYROS System) clearly reveal the qualitative differences in appearance that are objectively there.

Coming to a conclusion, this exemplary comparison of simulations of knitted fabrics leads to the following results: The CYROS System is very well suited for the simulation of the appearance of knitted fabrics made from OE-rotor-yarn, while the EXPERT System, on the other hand, is to be favoured for the simulation of fabrics that are made from ring-yarn.

Analyzing the Visual Appearance

So far, both 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. And now, for the first time, 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 evaluation 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.

With the aid of the digitized images the differences in brightness that are visible both, in the simulated as well as in the real knitted fabric, are allocated to various gray values. These gray values are then 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.

As the two physical systems, the EXPERT System and the CYROS System, have proven to be both suitable exclusively for the simulation of either ring-yarn fabrics or OE-rotor-yarn fabrics, the following comparison of the real fabrics and the simulated fabrics will be carried out

separately. This comparison aims at the confirmation of the statements that have been made about ring-yarns and OE-rotor-yarns.

Evaluation of the Fabrics Knitted from Ring-Yarn

The simulation of the knitwear made from ring-yarn with the EXPERT System demonstrates the even and homogeneous appearance. The distribution of gray values is much less contrastive than that of the OE-rotor-yarns fabrics.

The barryness that is typical for fabrics knitted from ring-yarn is reflected in the extremely course-oriented distribution of the „cloudiness" within the tested area, that is to say: it is reflected in the class-oriented distribution of the object frequency of bright and dark clouds. Therefore the object frequency is represented exemplarily for the evaluation of the appearance of real and simulated ring-yarn-fabric with the ITAOPT System. It is qualitatively and quantitatively comparable for both fabrics, the real and the simulated (Fig. 3)

Evaluation of the Fabric Knitted from OE-Rotor-Yarn

The comparison of the two genuine OE-rotor-yarn fabrics that have been evaluated objectively, Mic. 4.3 and Mic. 4.6, reveals the minor quality of the appearance of the fabric knitted from the OE-rotor-yarn, Mic. 4.6. This conclusion can be drawn from the higher spread of the gray values and from the higher contrasts between the bright respectively the dark areas and the standard areas (Fig. 4).

Just as for the ring-yarn fabrics, the distribution of the „cloudiness" within the tested area does also serve as criteria for the specific appearance of fabrics knitted from OE-rotor-yarns. The characteristic class-oriented distribution of the object frequency of the bright areas is therefore represented in Fig. 5, which compares the real and the simulated fabrics knitted from OE-rotor-yarns. The stronger course-orientation of the „cloudiness" of the OE-rotor-yarn fabric, Mic. 4.6, clearly appears both, in the simulated and in the genuine fabric. This comparison authenticates once more that the simulated fabrics are indeed qualitatively and quantitatively comparable to the real ones.

Summary

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. Both simulations can profitably be applied as prediction devices for the industrial use and for research or developmental purposes. The systems CYROS and USTER EXPERT, both used for the simulation of the appearance of knitwear, differ with regard to the structural attributes that are measured.

For the EXPERT System 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 especially suited for ring-yarns. With the aid of the simulation it is possible not only to emphasize the more homogeneous and the brighter appearance of the ring-yarn fabric as opposed to the two OE-rotor-yarn fabrics, but also to reflect the barryness that is actually there in the original ring-yarn fabric. The minor differences between the two OE-rotor-yarns influence the evenness of the yarn mass only insignificantly. Therefore these differences cannot be worked out satisfactorily with the aid of the EXPERT System.

For the CYROS System Can Be Stated:

The simulation of the appearance of various OE-rotor-yarns is possible on the base of the optically efficient yarn diameter. The CYROS System 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.

Nevertheless, the characteristic differences between the appearance of the ring-yarn fabric and the OE-rotor-yarn fabric cannot be inferred from the simulations to the same extent as they are actually visible for the veritable fabric. Surprisingly, the barryness which is typical for ring-yarn fabrics and which is visually obvious in the real fabric, cannot be detected by means of the evenness of the optically measured yarn diameter, but it can be detected with the evenness of yarn mass.

For Fabrics Knitted from Ring-Yarn Can Be Stated:

The yarns that are used especially for knitwear are yarns with a very low twist rate and a high hairiness, because these yarns guarantee the soft handle of textiles. Because of the hairiness it is quite helpful independently for the predictability of the appearance of fabrics knitted from ring-yarn that the parameters are measured independently. In this case, it is advisable to make use of the EXPERT System, because here the hairiness and the evenness of the yarn mass are measured independently of the yarn evenness, which is characterized by the optically efficient yarn diameter which, for its own part, can easily be falsified by the hairiness.

For Fabrics Knitted from OE-Rotor-Yarn Can Be Stated:

Unlike the structure of ring-yarns the structure of OE-rotor-yarns is characterized by the variation of yarn density across the cross-section. The variation of the yarn density is also responsible for the fact that a visually obvious thin or thick part in the OE-rotor-yarn is not necessarily accompanied by an increase or decrease in mass. Therefore it is advisable to

use the CYROS System, which is based on the optical yarn diameter, for the predictability of the appearance of fabrics that are knitted from OE-rotor-yarns.

Conclusions

The combination of the simulations with the ITAOPT System for the objective evaluation of the appearance of knitted fabrics allows statements about the quality of simulated knitted fabrics in comparison to genuine fabrics that are knitted from the same yarns. The values of the objective analysis of the surface of simulated fabrics that are obtained by the ITAOPT System are qualitatively comparable to those of the real fabric. The algorithms for selection are therefore suitable for the estimation of the quality of simulated knitted fabrics in comparison to veritable fabrics.

This objective evaluation elucidates that the more even and less contrastive appearance of the fabrics knitted from ring-yarn as opposed to those knitted from OE-rotor-yarns, is much more obvious, when simulated with the EXPERT System. In the same way, the differences between the two OE-rotor-yarns Mic. 4.3 and Mic. 4.6 are worked out more clearly with the CYROS System.

The ITAOPT System which has been newly developed at the ITA, offers new economic perspectives for yarn management, because it replaces the subjective visual evaluation of the appearance of simulated knitted fabrics with an objective, qualitative and quantitative analysis of these surfaces.

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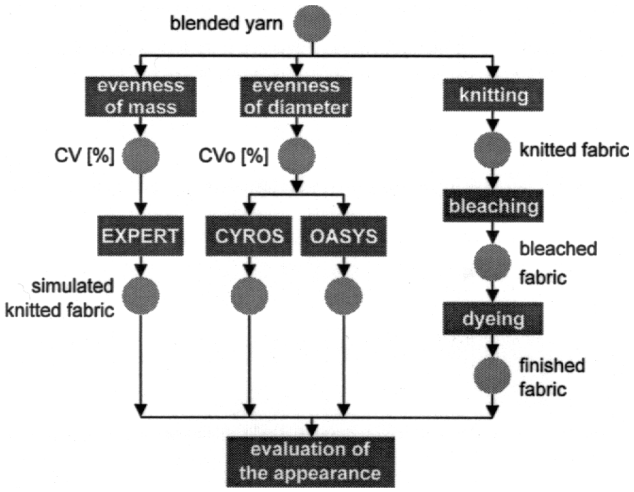

Figure 1. Engineering of knitted fabrics.

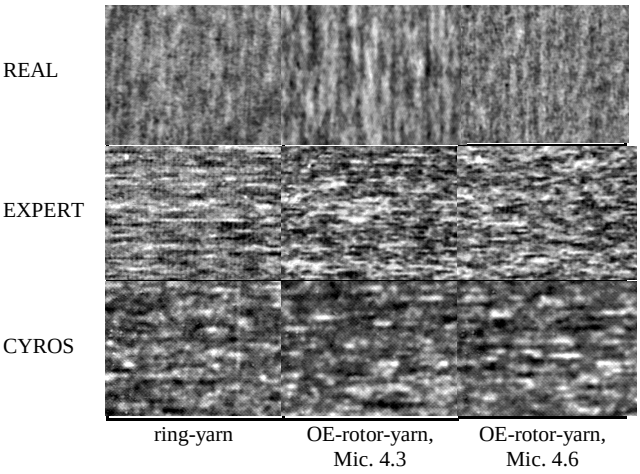

Figure 2. Comparison between real and simulated digitized knitted fabrics.

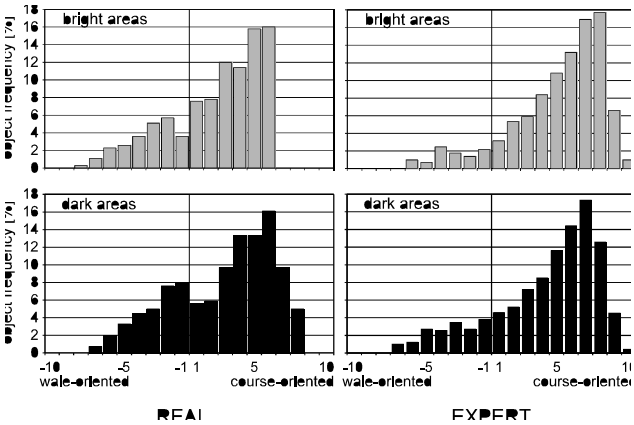

Figure 3. „Cloudiness“ of real and simulated fabrics knitted from ring-yarn.

		extension of gray values	contrast of bright areas	contrast of dark areas
REAL	OE-rotor-yarn, Mic. 4.3	36	0.93	0.92
	OE-rotor-yarn, Mic. 4.6	45	0.91	0.91
CYROS	OE-rotor-yarn, Mic. 4.3	36	0.81	0.83
	OE-rotor-yarn, Mic. 4.6	68	0.77	0.76

Figure 4. Evaluation of the appearance of real and simulated fabrics knitted from OE-rotor-yarn.

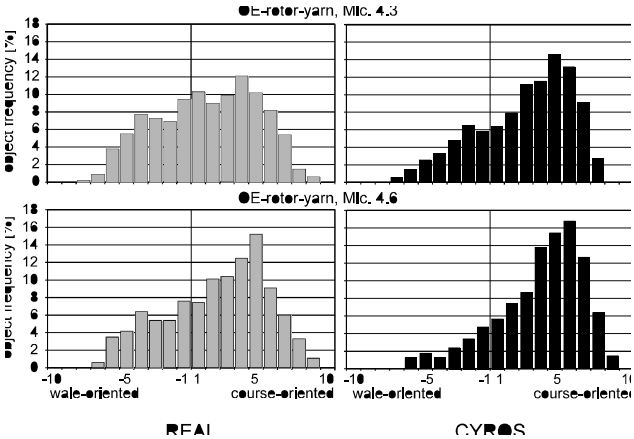

Figure 5. „Cloudiness“ of real and simulated fabrics knitted from OE-rotor-yarn (bright areas).