Demands made on the quality of yarn and fabric in the high-efficiency weaving plant

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The ambiguous term "Quality" has been defined as the degree of fulfilment of all the functional and fashionable requirements of a particular product. Fabric quality requirement comprises the fabric properties and fabric defects. Various attributes to the fabric quality have been discussed in detail. The end use applications of different types of fabrics have been differentiated based on the quantifiable physical data and the characteristic features which are subjectively assessed. The developments in yarn and fabric quality and the share of investment in shuttleless weaving during the last two decades have been enumerated. The contribution of continuous search of the weaving machine manufacturers towards achieving the quality fabric is highlighted.

Keywords: Fabric defects, Fabric quality, Weaving

1 Fabric Quality and How it can be Influenced

1.1 What is Fabric Quality?
Even in textiles, quality has become a necessity, and for many a manufacturer in a heavily contested market with greatly differing labour costs and ecolaws, it is often the only remaining life insurance. Thinking in terms of quality is nothing new. However, its meaning extends over a far wider range today. With the demand for manageable proportions of the existing interdependences, arises the problem of how to assess quality. Even if the value of quality can be assessed in the first place, it must be calculated differently for the filter fabric of a waste-gas plant or an artificial blood vessel, and for the lining fabric of ladies' or men's outerwear. The consequences that may be triggered by an undetected fabric fault are incomparable. But even with regard to our garments, the valuations of fashion and practical usefulness up to care regulations differ considerably.

Independently of the subjective consumer philosophy, fabric quality can be defined as an expression describing the degree of fulfillment of all the functional and fashionable requirements of a certain type of fabric.

As shown in Fig.1, the quality demands are associated with the practical value and fabric properties which can be derived from the ability of the fabric to be further processed as well as with the behaviour of the fabric in the case of defects. While, in general, the practical value refers to the finished fabric, fabric defects before and after finishing are checked and valued separately, since there is no coercive identity between these two.

1.2 What Influences the Quality of a Fabric?

Since the quality requirement comprises the fabric properties and the fabric defects, there is a complex interdependence between a multitude of influencing parameters. Their interlacing may extend from the raw material through the various process stages to finishing. The flow chart (Fig.2) shows, in a schematic way, the interaction of the essential influences between requirements and their ability to be satisfied. Even though by selecting the style, i.e. by defining the raw material, type of yarn, thread density and weave, the physical data of the fabric to be woven are fundamentally predetermined, a great number of

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**Fig. 1—Aspects of fabric quality**
diverse quality demands can be adequately fulfilled only by optimizing process-dependent influences of spinning, weaving and finishing.

There is a vast difference between the quantitative influencing of the two areas of fabric quality. So, the influence on the fabric properties, which can be derived from the weaving process, is rather small compared to that on the creation of fabric defects. To illustrate such a quantitative influence, a three-dimensional presentation has been chosen (Fig.3) which shows the fundamental differences between the various influences on the fabric properties, and on the creation of fabric defects.

2 Demands Made on the Fabric Properties
The demands made on the fabric properties differ with their areas of application. Fig.4 shows the principal differentiation of fabrics for:
garment textiles,
home textiles, and
— technical and engineering textiles.
In correspondence with the demands, the criteria of assessment dominate considerably. Global differentiation is made between the exactly quantifiable (measurable) characteristic physical data of the textiles, such as strength of the fabric, resistance to further tearing or its shrinking behaviour and the various fastness tests on the one hand, and the characteristic features which are mainly subjectively assessed, like drapeability, feel and appearance of the fabric on the other hand. The latter, which can be subsumed to fabric aesthetics, may be the only decisive criteria for the acceptance of a certain type of fabric to be used for making garment. In this context, the possibilities afforded by modern fabric finishing are gaining increasing significance. With industrial fabrics, however, the physical data of the fabric are normally dominant. So, the fabrics for industrial applications must meet the requirement of narrow tolerances with regard to strength, deviations in density or air permeability. With home textiles, fashion and physical demands are, as a rule, of equal importance.
The fabric defects must be considered independently of the fabric properties. Their diversity hinders standardized assessment.

3 Demands Made on the Fabric Behaviour in the Case of Defects
Fabric faults are either the rare local deviations from the fabric appearance or the disturbances of the fabric structure, which, as a consequence, may lead to either visible changes in the fabric appearance or to locally limited changes in the fabric properties. The causes of fabric defects can be extremely varied and, in many instances, they are the result of a causal system which embraces the raw material as well as all the preliminary processes from yarn production through weaving preparation to the weaving process.
Since the defects of grey and finished fabrics can either not be repaired at all or only at a heavy expense, minimizing fabric defects has become indispensable with high-performance weaving. Hence, the problem of fabric defects, with the objective of maximum faultlessness, is today's most important quality criterion in the weaving mill which leaves no room for compromises regarding the standards agreed upon.

Fig. 5 shows the tendency of ever tightening demands for the limitation of the permissible number of defects per fabric length, as they are normally valid for cotton weaving plants and 1st class fabric of 100 m length. While 20 years ago a limitation to 15 defects was accepted, today the maximum tolerable limit is 5 defects.

4 Development of Fabric Quality During the Last Two Decades

Today's standard of fabric quality reflects a development which has mainly taken place during the past two decades. It is that period of time in which the share of shuttleless weft insertion systems was constantly on the increase, as is evident from the time ratio of the investment (Fig. 6). It is a quite remarkable fact that the speed of the spinning and weaving machines could be doubled along with this quality development.

Enhanced fabric quality, in spite of higher speed, is not only the result of increased process dependability and optimization of process functions, but also of continuous improvement in the quality level of the yarns to be woven. This statement is true for the majority of all types of filament and spun yarns. The progress is best confirmed by the Uster statistics concerning fibre yarns. Since the raw material basis for natural fibres remained fundamentally unchanged, these improvements in the quality of ring-spun cotton yarns, for instance, do not touch the basic properties, but rather those characteristic quality variables that can be influenced by spinning technological means. These characteristic variables comprise, besides deviations of the yarn mass, in particular the thin places and fluctuations of the yarn strength which are most important for fabric production on high-efficiency weaving machines. Both thin places and fluctuations of the yarn strength correlate strongly with the weak points that give rise to thread breaks. Figs 7 and 8 show the decrease in $CV_{\text{max}}$ and thin places on the example of the 50% line of Uster statistics for ring-spun cotton yarns of count 10 tex. The significance of fluctuations of the yarn strength is evinced by the fact that about 2% reduction in the coefficient of variation of the yarn strength may entail a tenfold reduction in the weft breakage rate.

An even more marked trend towards quality enhancement is shown by the open-end or rotor-spun yarns. In this sector, an improvement in yarn strength could be attained, even though the spinning technological potential has not yet been fully exploited. Generally, great care must be taken so that the increasing spinning speed does not cause...
excessive loss of the yarns' elongation at break. Worsted spun yarns have also seen an improvement in quality in the past few years without which it would not have been possible to substitute the classical twists by single-end yarns in the weft to the extent by which this is presently done.

Of course, the progress in terms of fibre quality is also the result of constantly increasing in-depth quality control, all the way from the raw material to the spinning machine. So, today's cotton spinning industry is in the position to exactly adapt the raw material blend to the yarn's profile of requirements by analyzing the most important fibre characteristics. The precondition which must be met before the adaptation work of this kind is carried out is that the operator who is to perform this job should be aware of the intended application of the yarn and of the technical details of its further processing. Besides, it must be taken into account that the demands to be made on knitting yarns are not identical with those which must be imposed on weaving yarns.

5 Consequences to the Developments in Weaving Technology

As already mentioned, the improvement in yarn quality has positive consequences on the fabric quality. This is true for the fabric appearance as well as, directly or indirectly, for quantity and frequency of fabric defects. Doubtlessly, it is due to the enhanced yarn qualities that the technologically possible increase in machine speed could be successfully implemented in practical field use. This applied particularly to the weft insertion process where higher yarn speeds inevitably entail higher yarn strain. The causes and interdependences of yarn strain, which differ fundamentally for warp and weft, are well known nowadays. These findings have been confirmed by measuring the actual tensile peak loads acting on the individual threads in practical industrial use - a technique which has been made possible only recently. Since not only the yarn properties, particularly yarn strength or elongation, are subject to fluctuations but peak loads also vary, thread breaks are prone to occur whenever maximum forces are acting on the yarn sections of minimum strength or elasticity. The frequency distribution compared to weft peak loads (Fig.9) shows, by the example of an actual case, that the variation in the yarn strength of combed ring-spun cotton yarn is five times that of the peak loads. This confirms the paramount significance of yarn quality. The spreading which is increased several times through the influences of the yarn (at least in the case of fibre yarns) can, even in future, not be compensated by any control-oriented measures that concern the weft insertion process and which would have to be carried out on the weft insertion machine.

Irrespective of these aspects of the yarn quality, weaving machine manufacturers keep searching for means and ways enabling the increasing yarn loads, set up by the rising weft insertion rates, to be influenced by the targeted modifications to the weaving machines. Solutions such as controlled thread braking in connection with weft insertion have already been implemented in practical weaving. Thus, the thread's tensile force has turned out to be one of the most important process variables. Now, a promising approach to the problem solution is online collection of these values, long-time and as exactly as possible, with the aid of cost-effective measuring transmitters and to utilize the collected data for functional optimization via control processes. Besides, there are many subunits, like controlled warp let-off, back rest rollers and cloth take-up motions, which are also instrumental in enhancing the technological progress and fabric quality. The
application of electronics will set the pace for future innovations. Yet, even for the future, there is no universal quality assurance system in sight for the bidirectional processing of all the influences that have bearing on the weaving process and, finally, on the finished product. The mathematical model of such a complex control loop would have to comprise the monitoring and controlling of all the process variables which influence fabric quality; however, this is beyond all feasibility.

The attainable objective of future design engineering for weaving machines will certainly not focus exclusively on increasing machine speeds, but rather on technological process optimization and dependability. The subject of tasks of this kind will be finding solutions for minimizing thread strain as well as duration and frequency of machine stoppages. All these measures let us expect the realization of future quality enhancements and the dominance of the weaving process in producing textile surfaces.