SINGLE FIBER BASED DETERMINATION OF SHORT FIBER CONTENT

Th. Schneider, D. Rettig, J. Müssig
Faserinstitut Bremen e. V.
Bremen, Germany

Introduction

Today, there is no worldwide harmonised or even standardised testing method to measure fiber length. The terms used to describe fiber length are not standardised either.

None of the known length measurement methods is sufficiently sophisticated to measure short fiber content; the analysis of subsections of fibers is not suitable for the measurement of short fibers.

As a rule, sample preparation is problematic; handling guidelines must be drawn up and observed accordingly.

Worldwide, a multitude of raw cottons is commercially available - with manifold and varying properties and prices. The processing industry is subject to economic constraints which force it to adapt to quickly changing raw material properties. Knowledge of individual origins based on long-standing experience are of little use in this situation, so that the call for an improved quality assessment is entirely justified. Based on this situation different research projects have endeavoured to gain more insight into the distribution of properties within a natural, renewable resource such as raw cotton. The fact that natural fibers are internationally traded merchandise is in itself an obligation to increasingly harmonise fiber testing methods. This paper describes the realisation of a single fiber based system to determine fiber length and its distribution within a cotton sample.

The length of cotton fibers is of fundamental importance for the processing properties of the raw material; especially yarn count and strength strongly depend on the length of fibers and their distribution.

An image analysis system which records the length of fibers with an electronic CCD camera must be able to follow the outline of individual fibers irrespective of their degree of crimping or viewing angle. The only necessary calibration is to define a known section length using a normal, commercially available length standard.

Requirements for a Testing Procedure

Testing methods are only viable in the market if they enable the industrial user who relies on them to obtain fast, reliable and commercially sensible results to work with given production parameters. Reliability and repeatability in particular are criteria which are presupposed in modern measurement methods. A continuous challenge in the interplay between the development of testing equipment and textiles machinery engineering is to meet the need for exact and comprehensive characterisation of natural, i.e. individual raw materials by measurements. It is interesting to note that most mass testing methods for cotton use a mean value to describe the sample under review; the distribution remains unknown. It is obvious that one can not infer the distribution of a property from such a mean value. Modern fiber test equipment should enable external calibration using defined standards.

Concerning the achievable degree of spinning (yarn counts) and the obtainable yarn strength and tenacity, fiber length is of central importance among the other factors. The usual description of the mean staple length is no longer sufficient even with today's state of development of spinning machine engineering and technology. Also, in measuring fiber length there is a growing trend toward measuring characteristic distributions. For practical application this means that a basic method must be devised to create the preconditions to calibrate commercially available testing equipment.

The method described here is the first to enable assessment of the actual fiber length irrespective of crimping. All fibers are tested in an unstretched, non elongated state.

The objectiveness of fiber length measurement using image analysis is due to the exclusion of the usual operator induced influence; testing environment related factors such as temperature/humidity and state of the equipment must obviously be observed (cf. respective standards provisions applying).

Traditional Testing Methods for Length and SFC (Bremen Cotton Round Trial)

In the *Bremer Baumwoll-Rundtest* (Bremen Cotton Round Trial), traditionally the following fiber length testing methods are analysed:

	Equipment	Result
-	Digital Fibrograph	Fibrogram
-	HVI-line	Fibrogram and handclassing equiv. staple ≅ 2.5% SL (UHM) ≅ 25% L(W) Almeter
-	AFIS	staple diagram
-	Comb staple equipment	staple diagram
-	Almeter	staple diagram

All equipment with the exception of the comb staple equipment, Almeter and the AFIS indicate mean fiber lengths or span lengths respectively. Exceeding this, the comb staple equipment, the Almeter and the AFIS also give a measured description of the short fiber content (fibers ≤ 12,5 mm). Table1 shows an overview (mean values).

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1511-1512 (1998)
National Cotton Council, Memphis TN

Table 1: Overview (Bremen Cotton Round Trial 3/97).

	SFC(N), %	SFC(W), %
Digital Fibrograph	5.2 – 20.1	13.0 – 18.2
Comb Sorter	5.5 – 60.3	7.0 – 20.0
Almeter	12.2 – 42.6	4.7 – 20.6
HVI (ICCS)	7.7 – 19.8	6.4 – 16.4
HVI (HVICCS)	6.4 – 18.8	3.5 – 23.0
AFIS	19.8 – 46.8	6.2 – 19.5

Sample Material, Experimental Methods And Findings

For the tests we used several origins which are commercially available in the German market. All cottons were analysed using the testing methods mentioned above. The cottons were measured under the standard conditions of 65% +/- 2 % relative humidity and 20°C +/- 2°C temperature. Samples were taken in accordance with DIN 53803, which specifies that samples are to be taken from a random scatter. Table 2 shows all reviewed origins and the associated customary properties.

Tble 2: SFC by number of the used cottons.

Provenience	HVI ICCS, %	HVI HVICCS, %	AFIS, %	Image analysis, %
Mexico Juarez	23.0	29.1	26.5	33.3
Zimbabwe Albar	16.8	11.4	19.1	25.7
US – Pima	6.2	9.5	20.7	23.3

The schematic diagram of the set-up for image analysis to measure fibers with a PC is shown in fig. 1. Fig. 2 explains the steps of digital image analysis.

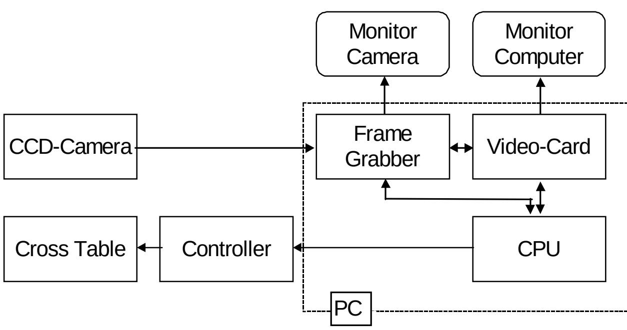

Figure 1: Image analysis system.

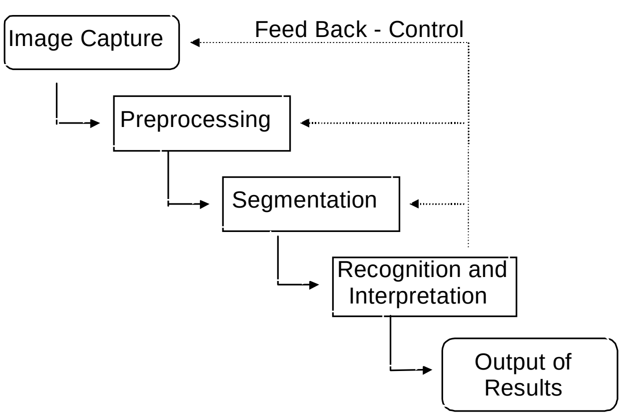

Figure 2: Steps of Digital Image Analysis.

To prepare the length measurements, approximately 10.000 single fibers are put on a base covered with black velvet. Fibers are then singled using the needle field of the comb staple device. The base which measures 50 x 50 cm is moved by a motor controlled cross table. This cross table is controlled by a PC-based program we developed. The CCD camera which is installed above the cross table digitises a field measuring 3,4 x 2,5 cm and transfers the data to the image analysis software. The camera resolution is 768 x 572 pixels. The software we developed is based on the Optimas program V5.1 produced by Optimas Cooperation. Since there are no commercially available universal image analysis methods we had to especially develop an analysis program to meet the requirements described above. The program was developed using the Software Pascal BP 7.0 and in Delphi I respectively.

Determination of short fiber content using the image analysis method to our current knowledge generates repeatable results. It is particularly notable that there is a distinct profile of fiber length distributions characterised by two maximums (fig. 3). Traditional testing methods can not see the left maximum since they completely ignore very short fibers. This is obviously not a natural phenomenon but rather an effect which is induced by the ginning process. We have reason to assume that the ginning not only separates the fiber from the seed, but also breaks some of the fibers. This fact must be corroborated by further studies.

Commercial Implications

Profit or losses in operating a spinning mill are often due to the right decision when purchasing the raw material. Despite modern equipment in the spinning mill, exaggerated cost of raw material can no longer be compensated by rationalising operations. Consequently, every mill manager will endeavour not only to buy good raw material at reasonable cost, but also to use it as efficiently and thoroughly as possible during the production process. This effort is often not supported by adequate testing equipment - concerning fiber strength, maturity and length, respectively. Raw materials which have the same mean index values for the above properties obviously do not necessarily have the same distribution of properties. Whether a raw material really meets the requirements concerning even distribution of properties can consequently not be determined. Assuming the purchased raw material is required to be as uniform as possible - also to avoid production problems–we may infer that testing methods are desirable which permit statements on the homogeneity of the raw material. The method presented here serves this purpose, which directly illustrates its commercial benefit.

Conclusion

Determining fiber lengths using PC based image analysis is generally suitable to determine length distribution and consequently the short fiber content. The results are in acceptable accordance with the usual traditional methods. A comparison of AFIS results with the image analysis findings shows good correlation. The testing method is based on software which we developed and permits precise characterisation of a given raw material. The raw material can be utilised more efficiently and thoroughly and downtimes in the spinning mill can be reduced due to more comprehensive characterisation of the raw material. The connection between the distribution and its causes indicate that a technology based reduction of the short fiber content is possible.

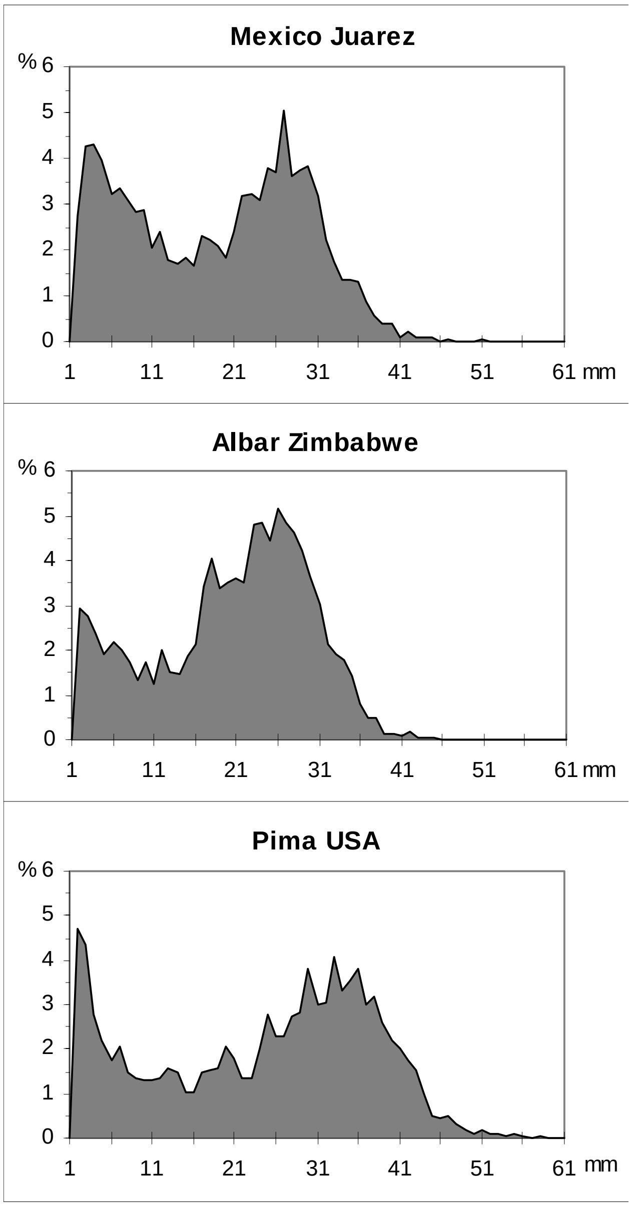

Figure 3: Distributions of fiber length.