USTER® HVI 1000

APPLICATION REPORT

Quality characteristics used for cotton classification

THE FIBER CLASSIFICATION AND ANALYSIS SYSTEM

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The Fiber Classification and Analysis System

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1 Introduction

The worldwide production of cotton reached a level of around 108 million bales or about 24 million metric tons in 2005. These figures indicate that cotton is a very important agricultural product.

For many decades the quality characteristics of cotton was determined by human classers. The human classer could categorize the fiber length, the color and the trash content quite well. However, it was difficult or impossible for him to determine the fiber fineness, the short fiber content, the strength, the elongation, the maturity, etc., of the cotton fibers.

There are 4 groups of people who had considerable interest to improve the determination of the quality characteristics of cotton:

- The cotton farmers
- The cotton traders
- The cotton research institutes
- The cotton spinners

The cotton farmer is mainly interested in getting incentives for a high quality cotton.

The cotton trader is interested in offering better services than the competitors and in determining the sales price according to the quality characteristics of the cotton bales.

The cotton research institutes need a sophisticated test system to do research work with internationally recognized quality characteristics.

The spinner has the intention to produce yarns of a consistent quality. For this purpose he needs the knowledge of the quality characteristics of the raw material for a constant and optimum fiber blend and for a correct setting of the machines.

During the three decades 1940 to 1970 various measuring systems for fiber testing were introduced in the market. Most of these instruments contributed to a more systematic measurement of quality characteristics, but the time span required to determine individual quality parameters was still considerable. The determination of an end-aligned staple diagram to measure the fiber length and the short fiber content with the Sutter-Webb or Johansson-Zweigle system took around 30 minutes.

The United States Department of Agriculture (USDA) played an important role to push faster test methods with the aim to determine all the quality characteristics of a cotton bale within a few seconds. USDA already started the first contacts with the American electronics industry in the late 1960s.
The way from the first attempts to replace the human classer was long and
difficult, and the testing system which was capable to measure the most
important quality characteristics within a very short time was named High
Volume Instrument (HVI).

2 Historical background

As a result of various difficulties in cotton trade, a resolution was passed in
the United States as early as in 1907 to establish uniform cotton standards.
The intention was to eliminate price differences between markets and to
settle disputes among the parties involved. At that time laws were passed
to authorize the United States Department of Agriculture (USDA) to develop
cotton grade standards and to offer cotton classification service [1].

3 Classification by human classers

For a long period, cotton was classified by certified human classers who
had to stick to some rules, benchmarks and grades, mostly those estab-
lished in the United States. However, as already explained in chapter 1, the
certified classers had the opportunity to determine few quality characteris-
tics quite well such as the fiber length, the trash content (compared to
grades), the color, etc., but a certified human classer had no sense to de-
termine other parameters such as the short fiber content, the maturity, the
strength, the elongation, etc. In addition, there was always considerable
variation among certified cotton classers, particularly because they were
hired a few weeks before the harvesting period, employed and trained only
before harvesting.

4 Classification by electronic instruments, a history

The United States Department of Agriculture already started to cooperate
with the US electronics industry in the late 1960s with the purpose to start
the development of the first “High Volume Instrument” with which the im-
portant cotton quality characteristics could be measured in a few seconds. The
first instrument was produced by Motion Control, Dallas, Texas, followed by
Spinlab of Knoxville, Tennessee. Both companies were acquired by Uster
Technologies in the early 1990s.

The first HVI Systems could measure the fiber length, the micronaire, the
fiber strength, the fiber elongation and the color.
5 Classification by electronic instruments today

The “High Volume Systems” have evolved to a sophisticated testing system in the past 35 years. Today a modern USTER® HVI System such as the USTER® HVI 1000 Classing contains all the sensors and hardware/software to measure fiber length, length uniformity, strength, micronaire, color and trash. Fig. 1 shows the USTER® HVI 1000 Classing and its subsystems.

6 Classing offices of the USDA in the US cotton belt

Today the USDA has 12 classing offices all over the cotton belt. As all of these offices have several HVI Systems, the organization is very effective. Nearly 100% of the US cotton crop can be measured during the harvesting season. Fig. 2 shows the Classing Offices between the West and the East coast of the USA.
7 International cotton classification

For the same reason as mentioned in chapter 1, some more cotton producing countries have adopted the US classification systems, some of them with a few adaptations to meet the local requirements. The two countries, apart from the United States with the most significant number of USTER® HVI Systems, are Uzbekistan and China. Uzbekistan started its cotton classification with electronic systems in the late 1990s and China in 2005.

Today there are more than 350 USTER® HVI Systems installed in classing offices worldwide.

8 Types of cotton

American Textile experts distinguish between two types of cotton:

- American Upland cotton (lat. Gossypium hirsutum)
- American Pima (lat. Gossypium barbadense)

American Upland cotton has its origin in Mexico and Central America. Up to 95% of the American crop can be assigned to this type of cotton. The characteristic fiber length of this cotton family is in the range of 22 to 34 mm (classer's staple).

American Pima is an extra long staple cotton in the range of 32 to 40 mm (classer's staple).

A third type of cotton exists in Southern Asia and Asia Pacific by the name of Gossypium herbaceum and Gossypium arboretum. This group of cotton is quite short and covers the range of 12,5 to 25 mm.

The long staple Pima cotton is finer than the Upland cotton and is mostly used for fine count yarns. Seed cotton, Pima type, is processed mostly by roller gins, whereas short and medium staple cotton is processed by saw gins.

The USTER® HVI Systems are able to process all the above mentioned cotton fibers.
9 Quality characteristics of cotton fibers

9.1 Fiber length

The most important length to be determined with the USTER® HVI Systems is the Upper Half Mean Length. This length is equivalent to the “classer’s staple” and is defined according to Fig. 3.

Fig. 3 represents the “Fibrogram”, which is a non-end aligned staple diagram.

The fiber length affects the yarn evenness, the yarn strength, the yarn elongation and the spinning process.

9.2 Fiber length uniformity

The fiber length uniformity is the ratio between the Mean Length and the Upper Half Mean Length (Fig. 3). This value is expressed in percent.

A low Length Uniformity at equal Upper Half Mean Length of two cotton bales indicates that the amount of shorter fibers is higher. This affects the spinning process and the quality characteristics of yarns. Low length uniformity increases the unevenness and decreases the strength of yarns.

9.3 Fiber strength

The fiber strength is determined at the same fiber bundle which is used for fiber length measurement. The jaws are placed 3 mm (1/8 inch) apart. The unit for fiber strength is Centinewton per tex (cN/tex).

For surviving subsequent processes, particularly the weaving process, yarns have to reach a minimum strength, and the yarn strength is determined by the fiber strength considerably.
9.4 Micronaire

The micronaire value is a measure of the fiber fineness and the maturity. The measurement of micronaire is based on an airflow principle. A cotton sample of 4 grams is entered into an airflow chamber. The finer and the more immature the fibers, the higher the resistance to airflow.

The micronaire value can influence the yarn evenness and the entire spinning process. Particularly the processing speed in spinning mills must be checked carefully to avoid damage to fine fibers.

Since immature fibers are also fine fibers, a low micronaire value can indicate the presence of immature fibers and, therefore, can affect the dye uptake in a fabric.

9.5 Color Grade

The Color Grade is a measure of the reflectance (Rd) and the yellowness (+b) of cotton fibers. These two quality characteristics can also be measured with the HVI System.

The determination of the color code is based on the Nickerson-Hunter cotton colorimeter diagram for Upland cotton.

The color code can be determined at the point where the reflectance Rd and the yellowness +b intersect on the Nickerson-Hunter scale.

There exists a relationship between the grades used by certified classers and the Nickerson-Hunter scale which is shown in Table 1.
The Nickerson-Hunter scale is shown in Fig. 5.

Example HVI: The reflectance Rd equals 66, the yellowness equals 11.4. The classification on the Nickerson-Hunter scale will lead to the following result: the two lines intersect in area 43, which is equivalent to strict low middling and spotted (see also Table 1).
As can be seen in Fig. 5, the areas 11 to 85 are mostly subdivided into smaller areas. The two lines in our example intersect in field 43-3.

10 Raw material statistics

Since most of the American cotton bales are classified, a large data base is available to identify the cotton quality characteristics of the US growing regions.

Since all the quality characteristics of the classified cotton bales are in the data base, the data is available to all the spinning mills which purchase US cotton.

The following is a practical example of classified HVI values.

Fig. 6 shows the strength of all the bales which were classified in the Classing Office of Dumas, Arkansas, USA, crop 2005.

The mean strength was 28.9 cN/tex. Approximately 90% of all samples were in the range 27 to 31 cN/tex.

Fig. 7 shows the frequency distribution of the micronaire values of the same classing office.
Approximately 90% of all the samples were in the range 4.1 to 5.1. The mean was 4.6.

In the Classing Office of USDA Dumas, Arkansas, 2,562,350 bales of the 2005 crop were tested. These bales had the following HVI mean values (Table 2, [2]).

<table>
<thead>
<tr>
<th>Quality characteristics</th>
<th>HVI values</th>
<th>Unit</th>
<th>Metric results</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronaire</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>34.7</td>
<td>1/32 inch</td>
<td>27.5 mm</td>
<td></td>
</tr>
<tr>
<td>Length Uniformity Index</td>
<td>80.8</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>29.5</td>
<td>gf/tex</td>
<td>29.5 cN/tex</td>
<td></td>
</tr>
<tr>
<td>Color grade 31</td>
<td>52.3</td>
<td>%</td>
<td></td>
<td>see Table 1</td>
</tr>
<tr>
<td>Color grade 41</td>
<td>24.0</td>
<td>%</td>
<td></td>
<td>see Table 1</td>
</tr>
</tbody>
</table>

Table 2
Mean values, classing office of Dumas, Arkansas, 2005 crop

11 Conclusions

The intention to establish uniform standards to classify cotton has already started nearly 100 years ago. However, for a long period the classification of cotton was a manual and visual procedure based on agreed standards.

After the Second World War electronic measuring systems came up to reduce the tolerance of the test results. However, the tests were still time-consuming.

The first attempt to increase the test speed of cotton classification was made by the United States Department of Agriculture in the late Sixties with the HVI. This test system has evolved in the meantime to a universal classification unit which has fulfilled the dreams of the pioneers.

Today, with the USTER® HVI 1000 a test system is available which can satisfy the needs of the cotton farmer, the cotton trader and the cotton research institutes and the cotton spinners. The quality characteristics determined by USTER® HVI Systems are known by everybody in the cotton supply chain.

Literature
