HVI: The System that has Revolutionised the Testing of Cotton Fiber Quality

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ABSTRACT

The development and introduction of the High Volume Instrument (HVI) system represents the greatest advance in cotton fiber quality testing this century. This paper discusses the history, application and benefits of the HVI system as well as some of the problem areas and future developments in this technology.

Introduction

The properties of cotton determine its cost, end use, processing cost and performance and ultimately the yarn, fabric and end-use cost and quality. This, and the fact that cotton can vary from bale to bale due to genetic, environmental, harvesting and ginning factors, make it essential that all the important lint properties be known for every bale (Table 1). In order to remain competitive in today's highly competitive market environment when new, high speed machinery is placing increasingly severe demands on fibers, the spinner must know the important textile properties of cotton and the way they determine processing performance and the cost and quality of the yarn and fabric. Cotton raw material accounts for between 50 and 75% of yarn manufacturing costs. Finally, the true textile quality of cotton must be quantified and reflected in its price for breeders, producers and ginners to provide mills with the most suitable cotton.

The need to accurately, practically and economically measure the important properties of cotton lint is apparent. Ideally, every cotton bale should be tested in the country of origin, and the results and other relevant information should accompany it (e.g. Permanent Bale Identification (PBI)), until it is processed in the cotton mill. Any re-test should be done by an independent testing facility on a "quick response" basis. It is the above needs that led to the development of cotton testing instruments and ultimately the HVI system. Undoubtedly, HVI testing of cotton is the best system and superior to traditional classing of cotton, in terms of providing an accurate description of the textile quality of the cotton. HVI properties explain from 80 to 90% of the variation in spinning and weaving efficiency, 60 to 80% of that in yarn evenness, 80 to over 90% of that in yarn strength and 70 to over 80% of that in fabric strength.

Historical Development of HVI Testing and Classing

The development of the laboratory instruments (for testing length, strength, micronaire and colour) in the 1940's and 1950's laid the foundation for the development of high volume systems, although they were far too slow for the volume testing of individual cotton bales. The next tentative step occurred in the early 1960's when the instruments were put together in assembly-line (conveyer) fashion, the first being developed by Motion Control for the Plains Cotton Cooperative Association in Texas in 1963. The first real step in the development of high volume testing systems occurred in 1963 when USDA met instrument manufacturers to discuss the development of instruments for the rapid measurement of the important fiber properties of every bale of US Cotton. The development of a rapid strength tester by Motion Control during the second half of the 1960's, was the breakthrough that enabled the HVI concept to become a reality. Motion Control was contracted by the USDA-ARS (through the Cotton Quality Research Station at Clemson) in 1965 to do this work. The real development of HVI's and a practical system for measuring cotton quality began in 1967. The first "high volume" system (by Motion Control), incorporating the measurement of length, length uniformity, strength and micronaire, and computer data storage, was installed at Texas Tech University in 1969. Therefore, it can be said that HVI "was born" in 1969. Field evaluation started in Raleigh in 1973, and in 1976 the USDA-AMS began comprehensive field evaluation trials in a classing office environment in Lubbock Texas, HVI systems being in operation at the USDA since 1976.

Video camera based trash measurement was developed in the late 1970's and added to HVI during the first half of the 1980's. In 1979, instrument measured length, as opposed to Classer's Staple Length, was reported as the official USDA staple length determination for the first time. The term "High Volume Instrument" or HVI was coined about then. HVI Classing first "went live" in West Texas in 1979. Large scale evaluation of the HVI Classification system, involving some ten HVI units purchased by a group of West Texas farmers, was carried out at the new "and first all HVI" Lamesa Classing facility in 1980. Some 300,000 bales were HVI Classed that year (98,000 in 1979). HVI Classing has been an option since then (in 1987, trash measurement were added to certain USDA HVI lines). Motion Control pioneered commercial development of

HVI, a second company, Spinlab, only entering the market a decade later. In 1989, the USDA HVI calibration cottons (HVI-CC) were changed to raw cotton.

Recognizing the importance of HVI, the ITMF International Committee on Cotton Testing Methods in 1988 formed an HVI Working Group that has over 50 members from some 20 countries today.

HVI Classing of American Pima cotton has been offered since 1990, and 1991 marked the first year that the entire US Upland cotton crop was tested by HVI and a strength premium/discount schedule introduced. Since 1993, the entire US cotton crop, including American Pima, has been HVI classified, Classer's Grade, however, still being done by the Classer. In 1992 Pakistan introduced its own Colour Chart for HVI.

In the early 1990's, NIR modules for measuring maturity and sugar content (the latter being discontinued not long afterwards) were added to a few HVI's. In 1990 Messrs Zellweger Uster acquired Spinlab and in 1994 also Motion Control Inc., thereby becoming the sole manufacturer and supplier of HVI systems. In 1997, however, another manufacturer (Premier Polytronics) entered the HVI market.

In 1995, the Universal Cotton Standards were expanded to include the USDA HVI Calibration Cotton, etc. The separation of Classer's Grade into Colour Grade and Leaf (Trash) Grade (in 1993), module/trailer averaging (in 1991), and rapid conditioning (in 1993) also represent important HVI related developments.

In 1997, the ITMF HVI Working Group prepared an HVI User Guide with a view to standardizing HVI test procedures and results worldwide, the ITMF distributing a total of over 2000 copies in more than 50 countries in the first year.

This year is another milestone, in that Uzbekistan, the third largest producer of seed cotton and second largest exporter of cotton, became the second country to use HVI to classify their entire cotton crop (based upon the US system) and for trading. Various other countries have made extensive use of the HVI system in the testing and classification of their cotton for a number of years.

At the 1998 meeting of the International Calibration Cotton Standards (ICCS) Committee meeting in Memphis it was decided that the micronaire only standards, also used for HVI calibration, would be changed from card web to raw stock.

The USDA is studying the conversion of Rd and +b to HVI Colour Grades that more closely match the Universal Colour Grade Standards, and the feasibility of using HVI colour as the official colour grade, with a view to it becoming the official method. Both the adjusted HVI Colour Grade and the official Classer's Grade are to be reported until the HVI Colour Grade is made the official grade.

A revised HVI short fiber content measurement, including a calibration procedure, has been developed by Zellweger Uster and is now to be extensively evaluated.

The modern automated HVI systems are virtually operator independent, require only one operator, and can test some 100 bales (200 specimens) per hour.

Growing use of HVI

The use of HVI Classing, as apposed to Manual Classing, improves the variations explained in (prediction of) yarn strength, appearance and neps and spinning performance by at least 40%, and today spinning mills worldwide are using HVI data to select bales for laydowns. For example, some 58 US mills (representing 95% of US cotton mills) and 17 mills in other countries, processing a combined total of some 12 million bales of cotton, use the HVI based EFS System.

Figure 1 shows the growth of HVI, in 1980 there only being 27 systems (26 Motion Control and 1 Spinlab) in place (all in the US), today there being over 1100 systems in 63 countries. This remarkable growth illustrates the rapid universal acceptance of HVI. Some 55% of all HVI's are used in spinning mills and the USDA use some 20% to classify the US cotton crop of almost 20 million bales. Cotton boards, growers, ginners, merchants, textile machine manufacturers, research institutes and universities use the remaining 25%.

HVI has found successful application in the following areas: Classing, Marketing, Trading, Pricing, Bale Selection and Laydowns, Breeding, Ginning, Prediction of Processing Performance and Yarn and Fabric Quality, Expert Systems, Computer Controlled and Aided Fiber Processing and Yarn Manufacturing.

The USDA, Cotton Inc. and the ITMF, through its International Committee on Cotton Testing Methods and HVI Working Group, have all played important roles in the international adoption and standardization of HVI testing.

HVI Calibration

The use of two sets of calibration cottons (HVI-CC and ICCS) for HVI, leads to different levels of HVI strength and considerable confusion, and to eliminate this, it is important that only one set of calibration cottons be universally used. Recognizing this, the ITMF HVI Working Group has twice recommended that only the HVI-CC be used and that the use of the ICCS samples for HVI be discontinued. Decisions taken at the 1998 ICCS Committee meeting in Memphis, particularly around the supply in future of only one ICCS calibration cotton with a length value,

represent an important step towards one HVI calibration level.

Moisture

Variations in the moisture content of the cotton beard at the instant of testing, plays a critical role in HVI strength variability, a change of 1% in moisture content changing strength by about 10%. It is not simple to keep the cotton beard moisture content constant or to accurately measure it, specifically the chemically bound moisture, at the instant of testing, this problem should soon be solved. Rapid conditioning, reducing conditioning time from typically 48 hours to some 15 minutes, represents an important step, although the precise level of the beard moisture content at the instant of measurement remains the critical issue.

HVI Reference Strength Tester

An important development flowing from the activities of the USDA, ITMF HVI Working Group and the Porto Group is the development of an HVI Reference Strength Tester for testing "benchmark bales" for HVI Calibration Cottons. This will help prevent a drift in HVI strength, provide an absolute strength level and facilitate improvements in HVI strength measurements. Units prepared at the USDA Clemson laboratory and placed in various centres around the world are now being evaluated in round trials. Results of the Bremen Round Trials, however, reassuringly indicate no drift in HVI strength over the past 7 years.

International Round Trials and Standardization

Two round trials, involving HVI, are carried out regularly, viz the monthly USDA Check Tests (introduced in 1984) and the quarterly Bremen Round Trials (HVI included since 1985). Some 140 laboratories participate in the Bremen Round Trials, some 170 in the USDA International Cotton Standards Check Test Programme and some 70 in the biannual USDA HVI Check Test Programme. Correct sample conditioning and preparation and calibration and test procedures, and participation in round trials, are very important in achieving acceptable inter-laboratory reproducibility that also compare favourably with those obtained on the laboratory instruments (Table 2).

Future Developments

There should be a steady growth in HVI systems into the next century, probably levelling off at around twice the number of systems in place today, the some 1100 HVI systems already being capable of measuring the entire global production of some 90 million cotton bales. The next generation of HVI systems will provide accurate measures of all the important fiber length (including SFC) and tensile properties, colour (possibly using a CCD camera/imaging colorimeter and different colour space co-ordinates), trash level and type (including seed-coat fragments), stickiness, micronaire, maturity and fineness, dyeability and "shiny neps" and will utilize different wavelengths of the electromagnetic spectrum (particularly, but not solely, in the NIR and VIS regions) to measure certain properties, notably those relating to colour (even "light spots"), dyeability, stickiness, fineness/maturity and "shiny neps". In the not too distant future, the accurate HVI Classification of cotton lint, without any human intervention, will be a fact.

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Table 1. Cotton lint quality characteristics that ideally should be measured and those currently measured by HVI.

VERY IMPORTANT			HVI
1.	Length and Length Uniformity		*
2.	Short Fiber Content		+
3.	Strength		*
4.	Non-Lint Content, Subdivided as Follows:		
	(I)	Average Trash (Level and Size)	*
	(II)	Trash Particle Size Distribution	0
	(III)	Trash Type	0
	(IV)	Dust: Level and Size	0
	(V)	Seedcoat Fragments	0
	(VI)	Foreign Matter and Contaminants (e.g. Plastics)	0
	(VII)	Cleanability	0
5.	Micronaire		*
6.	Average Maturity		+
7.	Single Fiber Maturity, Fineness and Distribution (Including "Dead" Fibers)		0
IMPORTANT			
8.	Colour		*
9.	Colour Uniformity		0
10.	Dyeability		0
11.	Neps (Size and Distribution)		0
12.	Elongation		*
13.	Stickiness (Mainly Honeydew)		0
LESS IMPORTANT			
14.	Friction (Probably Largely Related to Surface Wax		0
15.	Elasticity, Modulus and Work to Break (Related to some of the Above Properties		+
16.	Bilk or Crimp (Related to Convolutions and Other Properties))		0

* Can be Measured
\+ Can be Measured but Improvements and Development Still Required
0 Cannot be Measured

Table 2. Average inter-laboratory variation for laboratory "Stand Alone" instruments and HVI Systems (Bremen and USDA round trials).

Property		Average CVs (%)*		Average CVs (%)**	
		Bremen	USDA	Bremen	USDA
Micronaire	LAB.	3.1	3.5	3.1	3.4
	HVI	2.6	2.3	2.6	2.3
2.5% Span Length / Upper Half Mean Length	LAB.	2.4	3.0	2.5	2.9
	HVI	2.1	1.4	2.0	1.4
Uniformity Ratio	LAB.	3.8		3.8	
	HVI	3.9	4.0	4.1	4.1
Uniformity Index	HVI	2.3	1.2	2.2	1.1
Strength	LAB.	5.5	6.4	5.6	6.4
	HVI	5.7	5.0	6.1	5.0
Elongation	LAB.	9.5	13.7	9.8	13.7
	HVI	13.7	20.7	13.4	20.8
Colour Rd	HVI	1.6	2.0	1.5	2.1
Colour +b	HVI	4.1	5.0	3.8	5.2
Trash Area	HVI			133.7	
Trash Count	HVI			68.0	
Percentage Maturity	LAB.	7.6		8.0	
Maturity Ratio	LAB.	8.2		8.6	
Fineness	LAB.	7.9		8.1	

***** 1987 to 1997
****** 1991 to 1997