WORLDWIDE TRENDS IN COTTON FIBRE TESTING

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Abstract

There is an increasing worldwide trend towards the instrument testing of cotton, with the HVI and AFIS, which in many cases complement each other, presently the most important systems. This paper discusses some of the developments and trends in respect of these two systems.

Introduction

The physical characteristics of cotton lint largely determine the most suitable processing route and conditions, processing behaviour and efficiency (including waste) and ultimately the yarn, fabric and end-use quality. These aspects are reflected in conversion and product costs and ultimately the textile “quality” and "value" of the cotton. This, together with the fact that the cotton lint characteristics can vary, often quite independently, from bale to bale, due to genetic and environmental factors as well as harvesting and ginning conditions, make it essential that all the important cotton lint properties be known for every bale which a mill purchases and processes.

From the above, the need to be able to accurately, practically and economically measure and quantify those properties of cotton lint of importance in determining its utilisation, processing conditions, performance and cost and yarn and fabric quality and cost, is self evident. It is therefore hardly surprising that there is an ever increasing worldwide trend towards the routine instrument measurement of the quality characteristics of each individual bale of cotton, with the US leading the field. In terms of this trend, two systems, namely HVI and AFIS, particularly the former, stand out.

There can be little doubt that, in terms of the routine testing of individual bales of cotton for marketing, trading and processing purposes, the HVI system has been the most important development this century. Of increasing importance, and complementing the HVI, and particularly relevant to ginners and spinners, is the AFIS system, which is very useful for process improvements. The HVI system measurers fibre bundles and is extremely high speed, lending itself to the rapid testing and classification of individual bales of cotton. On the other hand, the AFIS system measures individualised fibres, neps and trash, is therefore slower, and is largely aimed at mill optimization. This paper will concentrate on these two systems.

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Cotton Lint Properties of Textile Importance

From the research carried out over many decades on the role of cotton lint characteristics in determining processing behaviour, performance and waste, spinning end breaks, yarn quality, knitting and weaving efficiencies and fabric and end-product behaviour and performance, it appears that, ideally, the values for the properties listed in Table I (some of which are inter-related) need to be known to completely characterise cotton lint in terms of its textile quality and value. Considerable progress has been made in this respect, particularly since the early 1980's, but further research worldwide is being undertaken to cover those characteristics not adequately covered by present testing systems, such as HVI and AFIS. Effort is also being directed towards developing on-line systems of measurement, which can be applied during ginning in particular, but also in the spinning mill, ultimately leading to completely computer controlled gins and spinning mills.

HVI Developments and Trends

Growth in the use of HVI

The worldwide growth in HVI is illustrated in Fig. 1, there now being some 970 complete and partial systems in place in 63 countries (see Table II), compared to fewer than 30 systems at the start of the previous decade. The USDA, Cotton Inc. and the ITMF, through its International Committee on Cotton Testing Methods and HVI Working Group have all played crucially important roles in the widespread international adoption and standardisation of HVI testing.

Approximately half of the HVI systems in place worldwide are used in spinning mills and close on a quarter are used by the USDA to classify the entire USA cotton crop of almost 20 million bales. The remaining HVI systems (ie one quarter) are used by cotton growers, ginners, merchants, textile machine manufacturers, research institutes and universities.

The recent extension of the Universal Cotton Standards Agreement, to include the current USDA HVI calibration cottons, laboratory atmospheric conditions and sample conditioning practices and procedures, also represents and important milestone in the instrument testing and classification of cotton as well as the official adoption and acceptance of the HVI system of measurement.

Table I shows the properties which can be measured by the latest HVI systems, such systems enabling the various listed properties to be measured in some 30 seconds using one operator only. Important developments this decade in the arena of HVI testing include the take-over of both Spinlab (in 1990) and Motion Control Inc (in 1994), by Zellweger Uster, resulting in only one HVI system now being marketed. The separation of Grade into Colour Grade and Leaf Grade, module averaging, reduction in calibration frequency and the universal standardisation of software and calibration systems, the rapid conditioning (5 to 10 minutes) of cotton samples as well as the measurement (eg NIR) of, and correction for, relative humidity and / or cotton moisture content at the instant of testing, also represent important developments.

Important developments required around HVI, and in fact taking place, include the characterisation of the type of trash (eg bark, grass, leaf etc), the measurement of honeydew (insect) specific sugars and the more accurate measurement of maturity and short fibre content.

HVI Calibration

Two sets of calibration cottons (HVI and ICCS) are still being used for HVI, leading to potentially different levels of strength, and it is therefore essential that calibration levels always be specified for strength. Attempts are being made to move towards the universal use of only one set of calibration cottons (HVI - CCS) and corresponding level.

HVI Reference Strength Tester

One of the most important developments flowing from the activities of the USDA, ITMF HVI Working Group and the Porto Group is the effort being directed towards developing a HVI Reference Strength Tester for testing "benchmark bales" for HVI Calibration Cottons. This will help to ensure that no drift takes place in HVI strength levels, provide an independent and more absolute strength level and also facilitate further improvements in HVI strength measurements. Good progress has been made in developing a semi-automatic (HVI based) strength tester which can prepare and test double transferred non-tapered beards, with the mass of the fibre specimen being determined directly by weighing if necessary.

Instruments have been prepared at the USDA Clemson laboratory and placed in eight centres around the world. These centres have been carrying out round trials in order to determine the interlaboratory reproducibility of the Reference Strength Tester. The "ideal bundle strength", derived from single fibre tensile tests on a Mantis or similar type of instrument, is intended to form the basis of reference for calibrating the Reference Strength Tester.

Problems which needed to be overcome include:

1) Correcting for fluctuations in moisture content.
2) Standardising brushing conditions and ensuring its consistency.
3) Avoiding a length biased result in the way the non-tapered bundle is prepared.
4) Changing the present HVI Calibration levels to that of the Reference Strength Tester. This is probably more a "political" than a technical / scientific matter. It is hoped that the incorporation of HVI into the Universal Cotton Standards Agreement will expedite this.

International Round Trials and Standardisation

Two different round trials (check tests) involving HVI instruments, are being carried out regularly, viz the USDA Check Tests (monthly) and the Bremen Round Trials (quarterly). Presently, some 140 laboratories participate in the Bremen Round Trials, some 170 laboratories participate in the USDA International Cotton Standards Check Test Programme and some 70 laboratories in the USDA HVI Check Test Programme. Correct sample conditioning, sample preparation and calibration and test procedures, together with the regular participation in such round trials, are critically important in improving inter-laboratory agreement and generally lead to acceptable inter-laboratory reproducibility and agreement of HVI results, which also compare favourably with the results obtained on the traditional laboratory instruments (Table III). Table IV provides some examples of typical interlaboratory HVI tolerances derived from the results of International Round Trials and Check Tests.

It is often assumed that an interlaboratory variation (CV) of 5% or less is required for a test to be internationally acceptable. According to Table III, and the assumed criteria of a CV of 5% or less, all the HVI tests listed in Table III qualify as having acceptable interlaboratory variability, except for Trash and Elongation, with Colour (+b) and Strength marginal. In the above context, the establishing of the International HVI Level Assessment Program, modelled after the USDA Check lot System, was also an important development. In this Programme, international organisations periodically send representative cotton samples to USDA's Quality Control Section in Memphis to cross check the HVI test results. In this Programme, signatories to the Universal Standards Agreement could serve as regional testing centres for affiliated organisations with HVI systems.

AFIS Developments and Trends

As far as, the complete instrument characterisation of cotton is concerned, there are important gaps in what can be accurately measured by HVI, notably neps and single fibre and trash particle dimensions. It is with these gaps in mind that the Advanced Fibre Information System (AFIS) was developed in the late 1980's by Schaffner Technologies in the USA to measure and characterise neps and individual fibres in cotton lint and sliver.

Subsequently (in 1990) this company and development were taken over by Messrs Zellweger Uster. The first AFIS unit to appear on the market towards the end of the 1980's was the AFIS-N, which was able to measure neps in cotton lint, without distinguishing between fibrous neps (ie entanglements), also referred to as mechanical neps, and seed coat neps. This was followed shortly afterwards by the AFIS-T for measuring trash particle size and number and the AFIS-L&D for measuring single fibre length (including short fibre content) and diameter. More recently, the AFIS F&M unit appeared on the market for measuring single fibre fineness and maturity and the adaption (SCN) to the AFIS-N to enable fibrous neps and seed-coat neps to be measured separately. The AFIS represents an important milestone in the quest for the complete instrument characterisation of cotton fibre properties and quality and, as already stated, is largely aimed at mill optimization.

The AFIS Maturity module was combined with the AFIS Length module, creating the "Length & Maturity" (L & M) module which became available at the beginning of 1996.

The acceptance and utilisation of the AFIS technology is growing rapidly (Fig 2), there today being 360 AFIS systems in place in 40 countries around the world.

The ability to measure single fibre maturity distribution, and dead fibres, fibrous neps and seed coat neps (also "shiny" neps) are critically important in being able to assess, and predict, the performance quality of cotton in terms of spinning behaviour, yarn quality and particular fabric appearance (notably barré and white or undyed specks / flecks).

Concluding Remarks

The cotton world has come a long way in its quest to objectively, completely and accurately characterise the textile quality and value of cotton by means of HVI and AFIS, particularly the former, but work is in progress to even further extend the scope and accuracy of both systems. The two systems largely complement each other, the HVI testing cotton fibre bundles and the AFIS individualised fibres, neps and trash.

What is extremely important in the case of HVI, is that all laboratories use the same (universal) calibration cottons, procedures and levels, testing procedures, correct sampling procedures and sample preparation and conditioning, and that they regularly participate in round trials. Equally important is that the atmospheric conditions (including short-term cyclical fluctuations), and particularly the moisture regain of the cotton at the instant of the strength test, be controlled to within very narrow tolerances (or else measured and corrected for). A challenge facing mills all over the world today is the effective utilisation of present and future HVI and AFIS data, in the most cost effective engineering of yarns and fabric of the desired quality, since there can be little doubt that this will provide a strong competitive edge.

Table I. Cotton Lint Quality Characteristics which ideally should be measured and those presently measured by HVI and AFIS.

LINT CHARACTERISTICS	HVI	AFIS
VERY IMPORTANT		
1. LENGTH AND LENGTH UNIFORMITY	*	*
2. SHORT FIBRE CONTENT	+	*
3. STRENGTH	*	0
4. NON-LINT CONTENT, SUBDIVIDED AS FOLLOWS:		
(I) AVERAGE TRASH (LEVEL AND SIZE)	*	*
(II) TRASH PARTICLE SIZE DISTRIBUTION	0	*
(III) TRASH TYPE	0	0
(IV) DUST: LEVEL AND SIZE	0	*
(V) SEED COAT FRAGMENTS	0	*
(VI) FOREIGN MATTER AND CONTAMINANTS (EG PLASTICS)	0	0
5. MICRONAIRE	*	*
6. AVERAGE MATURITY	+	*
7. SINGLE FIBRE MATURITY, FINENESS AND DISTRIBUTION (INCLUDING "DEAD" FIBRES)	0	*
IMPORTANT		
8. COLOUR	*	0
9. COLOUR UNIFORMITY	0	0
10. DYEABILITY	0	0
11. NEPS (SIZE AND DISTRIBUTION)	0	*
12. ELONGATION	*	0
13. STICKINESS (MAINLY HONEYDEW)	+	0
LESS IMPORTANT		
14. FRICTION (PROBABLY LARGELY RELATED TO SURFACE WAX)	0	0
15. ELASTICITY, MODULUS AND WORK-TO-BREAK (RELATED TO SOME OF THE ABOVEMENTIONED FIBRE PROPERTIES)	+	0
16. BULK OR CRIMP (RELATED TO CONVOLUTIONS AND OTHER PROPERTIES)	0	0

* CAN BE MEASURED
+ CAN BE MEASURED BUT IMPROVEMENT AND DEVELOPMENT STILL REQUIRED
0 CANNOT BE MEASURED

Table II. Countries with HVI Systems (31 December 1996)

Argentina	Germany	Malaysia	Taiwan
Australia	Ghana	Mali	Tanzania
	Greece	Mexico	Thailand
Bangladesh	Guatemala	Morocco	Tunisia
Belgium			Turkey
Brazil	Hong Kong	Nigeria	Turkmenistan
Burkina Fasso	Hungary		
		Pakistan	USA
Canada	India	Paraguay	Uzbekistan
Chile	Indonesia	Peru	
China (PRC)	Iran	Philippines	Venezuela
Columbia	Ireland (Eire)	Poland	
Czech Rep.	Israel	Portugal	Zambia
	Italy		Zimbabwe
Dubai	Ivory Coast	Rumania	
		Russia	
Ecuador	Japan		
Egypt		South Africa	
El Salvador	Kazakstan	South Korea	
England	Kenya	Spain	
		Sudan	
France		Switzerland	
		Syria	

The assistance of Messrs Zellweger Uster in preparing this Table is greatly appreciated.

Table III. Average Interlaboratory Variation for Laboratory “Stand Alone” Instruments and HVI Systems (Bremen and USDA Round Trials)

PROPERTIES		AVERAGE *CV'S (%)		AVERAGE CV'S (%)	
		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	1.9	1.4
UNIFORMITY RATIO	LAB.	3.8		3.8	
	HVI	4.0	4.0	4.2	4.1
UNIFORMITY INDEX	HVI	2.3	1.2	2.1	1.1
STRENGTH	LAB.	5.5	6.4	5.6	6.4
	HVI	5.6	4.9	5.9	4.9
ELONGATION	LAB.	9.5	13.7	9.8	13.7
	HVI	13.7	20.6	13.4	20.7
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			128.8	
TRASH COUNT***	HVI			67.8	
PERCENTAGE MATURITY	LAB.	7.6		8.0	
MATURITY RATIO	LAB.	8.2		8.6	
FINENESS	LAB.	7.9		8.0	

* 1987 to 1996
** 1990 to 1996
*** 1991 to 1996

Table IV. Example of Typical Interlaboratory HVI Tolerances (based upon International Round Trials/ Check Tests)

Property	Assumed Average	67%* Tolerances (±)	95% Tolerances (±)
Length (mm)	28	0.5	1.0
Uniformity Index (%)	80	1.3	2.6
Uniformity Ratio (%)	47	1.9	3.7
Micronaire	4	0.1	0.2
Strength (gf/tex)	25	1.3	2.6
Colour (Rd)	75	1.2	2.4
Colour (+b)	11	0.5	1.0

* 1 Standard deviation

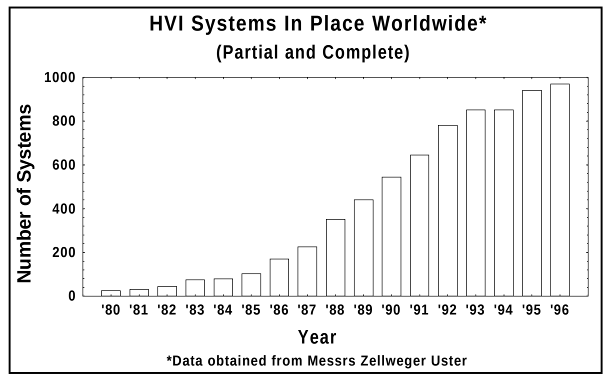

Figure 1. HVI Systems In Place Worldwide

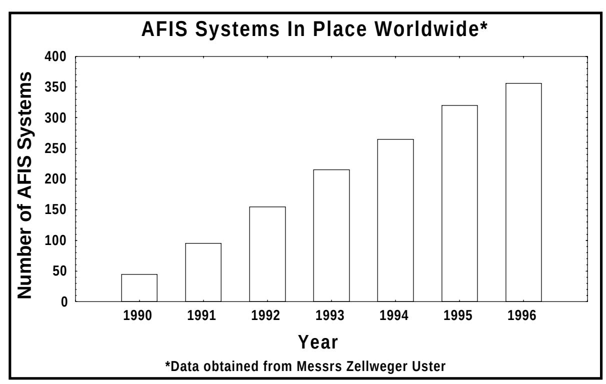

Figure 2. AFIS Systems In Place Worldwide