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HARMONISATION OF HVI STRENGTH CALIBRATION

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Abstract

The restriction of the International Calibration Cotton Standards means one step further towards harmonizing the measurement technology for fibers worldwide. Especially in Europe the users of HVI preferred the ICC-Standards to calibrate their equipment because of the reliability e.g. of the strength measurement based on the Stelometer-level. Others who used the HVI-Calibration Cottons came in conflict with users of ICC-Standards because of the different level focused on strength measurement. This situation led to some trouble and misunderstanding in the international trade of cotton, and problems also arose within the business between involved companies. Knowing this, some research was done at the Fibre Institute Bremen (Faserinstitut) to provide some scientific knowledge on the new situation focused on the calibration of HVI and the reliability of the results as well. The basis Stelometer is no longer available to check the HVI systems.

Introduction

Fiber quality measurements always have to be seen in the field of technology, quality and cost. The HVI-system is used as a fast equipment to get a 100 % bale control. This is important for the farmers, spinning mills and consumers as well. The textile engineering companies require a measurement technology, which evaluates physically based results, this means that the results should spread out the real mechanical behavior of the fibers. Pointed out from this demand it is necessary to use instruments, which are reliable and are ready to be calibrated on standardized levels for years. The demand of the German HVI Group just concluded 12 years ago to establish artificial standards for HVI. This was not realized up to now because the HVI-technology does not allow the use of artificial standards for strength calibration because of the implemented physical phenomenon. This report is a summary of two projects, which were conducted to evaluate a reliable calibration system for HVI strength measurement.

Methods

In an initial step the exact technical procedures for measuring within a HVI test line should be analysed in detail. No information was available concerning the internal programme flow of an HVI. In order to solve this problem, the steering mechanism of an HVI 910 was completely removed and replaced by a testing apparatus steering mechanism specially developed for this. In order to be able to compare the readings, which were to be created later, better, the hardware, that is the functions for brushing out, clamping and tearing of the bundles, as well as the system for monitoring the amount, was completely left in its original state. The steering and control was now taken over by a PC with stepping motor steering mechanism and a powerful I/O-card. The steering programme was realised with Lab View from National Instruments.

Besides the diagram of the normal running standard HVI test programme several other innovations were taken over into the flow during programming.

The trigger speed was reduced in a simultaneous mechanical stiffening of the HVI lever system. This enables the full force-elongation-curve of a tensile test of cotton bundles to be recorded.

In addition to this, there is a reversal of the HVI-clamps after the fibre bundle has been clamped. This way allows the force-elongation-curve starting from the force 0 to be observed, and, therefore, make it possible to give clear statements on the crimping features of a cotton bundle. In the normal HVI-test flow an initial tension is applied to the bundle, which prevents an exact assessment of the crimping features being made.

The measurement of the bundle elongation is not carried out by the position of the stepping motors, but a high precision extension receptacle was attached directly to the HVI-clamps. This enables a direct and exact observation of the elongation-curve and, therefore, the elongation features of a cotton bundle.

Yet another change concerns the determination of the maximum elongation of the tension. The analysis is not carried out from the starting point of the curve to the maximum elongation of tension. Here, the danger lies in the different crimping features of the cotton also being included too much in the entry of the readings. In this case the module of the force-elongation-curve was determined and the intersection of the module was used as a basis with the zero point of the force as a starting point for the measurement of the elongation.

Through the full determination of the force-elongation-curve the work, which was performed in the bundle can now be calculated. In addition to this, the decrimping work in the bundle can now be determined, too. The new characteristic values are shown in the schematic bundle force-elongation-curve in *Fig. 1*.

In order to monitor the strengths measured in the converted HVI the gravimetric control system of the USDA Reference-Tester was taken over. This way the torn fibre seam was separated exactly at the position base-amount and their mass ascertained on scales. First, the amount of the torn fibre seam is measured in the HVI. Through integrating the amount-curve over the length of the fibre the fineness of the bundle of the torn fibres can be calculated in connection with the accompanying fibre mass (Bragg, 1996).

Results

USDA standards (HVI, HVICC), and sufficient tested and well-known samples from the Bremen Round Trial were used as test material.

These cotton samples were measured using the modernised HVI-system. The test programme was carried out by various laboratory technicians, in order to be able to recognise whether it has an influence depending on the number of different people concerned. Additionally, repeat measurements were carried out. In *Fig. 2* the readings achieved with the gravimetrically ascertained bundle fineness in comparison with the known nominal values are shown (lower curve). The correlation is very good, however the readings are only at a level of approx. 60% of the nominal values at the Stelometer-level. This can be explained by the fact that, in comparison to a Pressley-bundle, an unfavourable bundle mechanism exists in a HVI-bundle. The fibres are present in a much higher number they are not well-parallelised and not initially tensed at an optimum level in the air current.

Nevertheless, an increase in the measurements to the Stelometer-level is possible with a suitable conversion using the following formulas (Baeumer, 2000).

$$F_f = F_h / A_{Br} * k$$

$$k = 1/(-0.1353 \cdot Mic^2 + 1.508 \cdot Mic)$$

F_f = Bundle tenacity
F_h = Maximum tension of the bundle
A_{Br} = Break Amount
k = Micronaire dependent corrective factor

The values measured and calculated with the purely optical process on the basis of the amounts correlate with a definition measurement R^2 of 0.94 compared with the stipulated nominal values (*Fig. 2* upper curve).

The elongation values ascertained with the HVI could only be compared with the elongation values of the Stelometer measurements from the Bremer Round Trial (*Fig. 3*). The bundle elongation which were determined with the help of the module ε_m, show a much clearer definition measurement (R^2) than the normal HVI-bundle elongation ε_0 . On average however they are still always approx. 2-3% higher than the Stelometer values. This too can be explained with the worse bundle mechanism compared with the Stelometer. A higher bundle elongation has to be accepted through the unfavourable parallelism.

Analysis of Round Trial data

Besides the experiments and the examination of the technical processes in the HVI the features of HVI test results in the well-known Round trials of USDA and FIBRE were analysed in another process. The prime aim was to be able to present the German and European textile industry with conversion factors, in order to be able to carry out conversions of characteristic values after the introduction of the restrictions of the ICC standards and the associated use of the HVICC level in Europe.

The authors know few details concerning the HVI-Check test of the USDA. Therefore, the Established Value known from the tests was compared with the means of all laboratories. The readings of Uniformity Index (*Fig. 4*) and Bundle Length (*Fig. 5*) conform pretty well. The comparison of the bundle tenacities gives a completely different picture. During the period from July 1996 to May 1999 the Established Value rose by approx. 1 g/tex (sample 1) or 1.5 g/tex (sample 2) compared with the means of all laboratories (*Fig. 6*). This excessive increase has dwindled again in the subsequent years up to today. This phenomenon could not be explained at first. A further analysis of the Bremen Cotton Round Trial was able to provide information on this.

As mentioned at the beginning already, the main interest of the tests, which were to be carried out, was in the comparison of the readings with various standard levels. A direct comparison of the strengths of ICC and HVICC can be seen in *Fig. 7*. In the case of a really good correlation a ratio of the standard level of 1.29 can be read. The readings taken as a basis are the Round Trial results of the past 10 years. The ratio of HVICC to ICC and to Stelometer during that period is shown in *Fig. 8*. The definition measurements R^2 are at 0.2 or 0.3 not very high, however the trend can clearly be seen. In the past 10 years there has been a continuous shift in the level of the HVI values of strength. The factor HVICC to ICC is not constantly 1.29, but increased from 1.26 at the beginning of the 90s to an actual value of 1.32. This is also confirmed by the readings of the same cotton round test sample, which were tested in different years. It is unclear whether the HVICC-level or the ICC-Level or both changed over the years. A direct comparison of Pressely 3.2 and Stelometer shows a dramatic reduction in the Pressely 3.2 level compared with the Stelometer Level (*Fig. 9*), however, there is still no evidence here, which of the two levels was subject to a change in the last few years.

For a more exact clarification several of the Round Trial samples were tested with a universal tensile testing machine (Instron). This process gives the advantage that similar basic conditions can be achieved as in the Stelometer test and therefore the readings are easy to compare. The testing machine is external, i.e. can be calibrated without cotton standards and the cotton fibres are clamped in Pressely-clamps and taken into a special clamp mounting. The preparation of the samples has been optimised even more in comparison to the Stelometer test. Through a constant parallelisation, decrimping and initial tension of all fibres in the bundle, nominally higher tensile strengths can be achieved.

The test series established however that the bundle tenacities measured on the Instron are on average 5% below the characteristic values determined by the Stelometer. This fact is seen as an indication that not the Pressley level fell in the last 10 years, but the Stelometer level rose during this period. The chronological development of the HVI-tenacity values (ICC and HVICC) at the relevant standard is very clear after the arithmetical correction. The HVICC level has risen therefore by 14%. This corresponds to an average increase of the bundle tenacity of 4.2 g/tex. The ICC level is still 10.3 % too high. This corresponds to an average increase of 2.4 g/tex (*Fig. 10*).

A time-based conversion factor could now be derived for the conversion of the bundle tenacities ICC level in the HVICC level (*Tab. 1*). The other conversion factors for the uniformity and the length are shown in the same table without any further comment. A conversion of the elongation is not necessary (Baeumer, 2001).

Summary

The HVI test system cannot achieve the same characteristic values for tenacity and elongation as are possible in the Stelometer process or in the Pressley process because of an unfavourable bundle geometry. The readings have to be raised to the Cotton Calibration Standard Level with the help of the HVI evaluation programme. As the tests showed the HVI system can indeed be calibrated without cotton standards. The reproducibility and exact repeatability is very good, influences caused by people can be disregarded. In this constellation the HVI can be installed as an established material testing system in accordance with ISO 9000. Through the restriction of the ICC standards independent controls will be even less possible in the future. We are not going to continue the discussion why the tenacity level of the cotton standards has risen by more than 10% in the last 10 years. However, in order to increase the confidence of the textile processing industry and the consumers, measures should be discussed and taken for the future that prevent the standard level drifting off even further.

References

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Baeumer, R. Anpassung von HVI-Anlagen an die Bedürfnisse der deutschen baumwollverarbeitenden Industrie AiF-Forschungsbericht 11602, 2000, Faserinstitut Bremen, Bremen, Germany.

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Table 1. Factors to Calculate HVICC Values from ICC Values.

Procedure	Factor		Remark
Strength [g/tex]	till 1994	$F_{f(HVICC)} = 1{,}28\ F_{f(ICC)}$	Factor changed in time
	till 1996	$F_{f(HVICC)} = 1{,}29\ F_{f(ICC)}$	
	till 1998	$F_{f(HVICC)} = 1{,}30\ F_{f(ICC)}$	
	till 2000	$F_{f(HVICC)} = 1{,}31\ F_{f(ICC)}$	
	till 2002	$F_{f(HVICC)} = 1{,}32\ F_{f(ICC)}$	
Elongation [%]	-		no calculation required
Length [mm]	$UHM = 0{,}925 \cdot 2{,}5\%SL + 2{,}293$		very good Correlation
Uniformity [%]	$UI = 0{,}47 \cdot UR + 60$		for mid staple Cotton
	$UI = 0{,}8 \cdot UR + 47$		for extra long staple Cotton

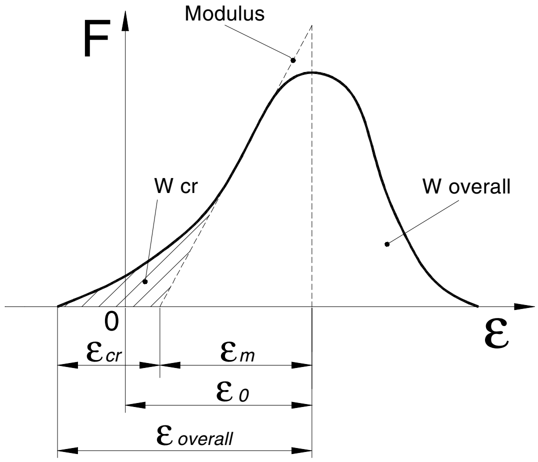

Figure 1. Bundle Force Elongation Curve schematic.

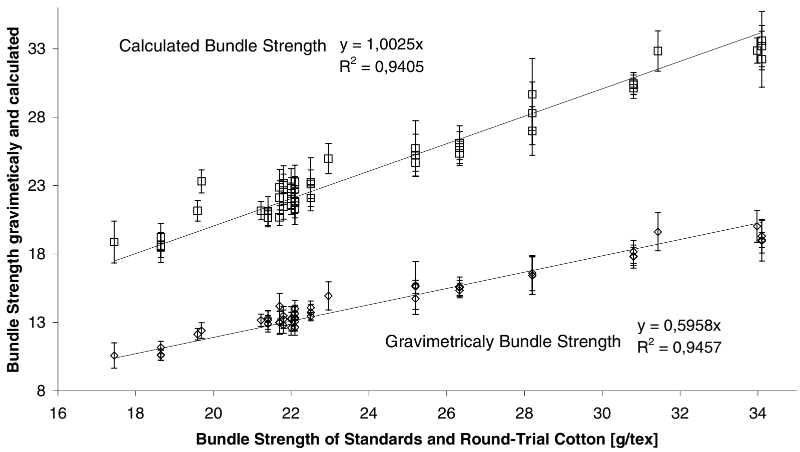

Figure 2. Measured and Calculated Bundle Strength.

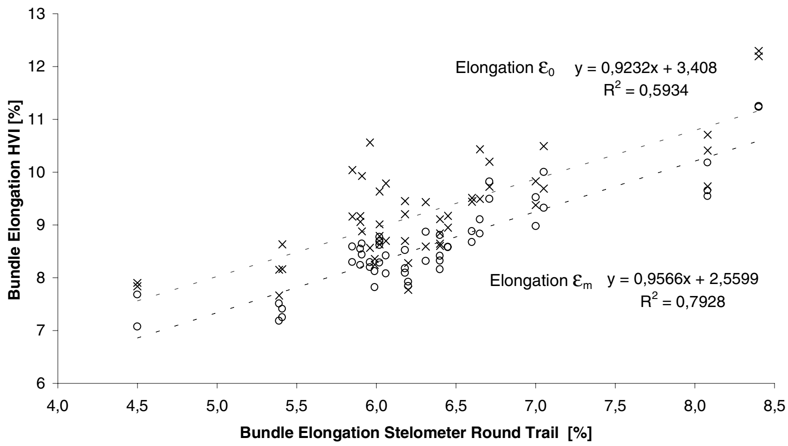

Figure 3. Results of Elongation Measurements.

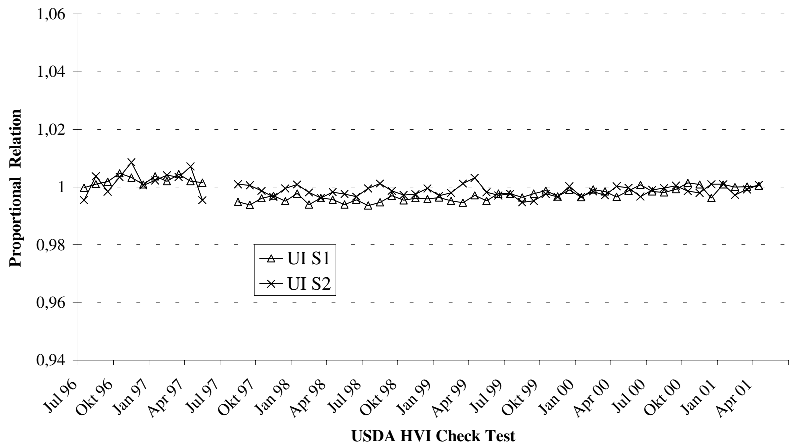

Figure 4. Uniformity Index from USDA HVI-Check Test (Sample 1+2).

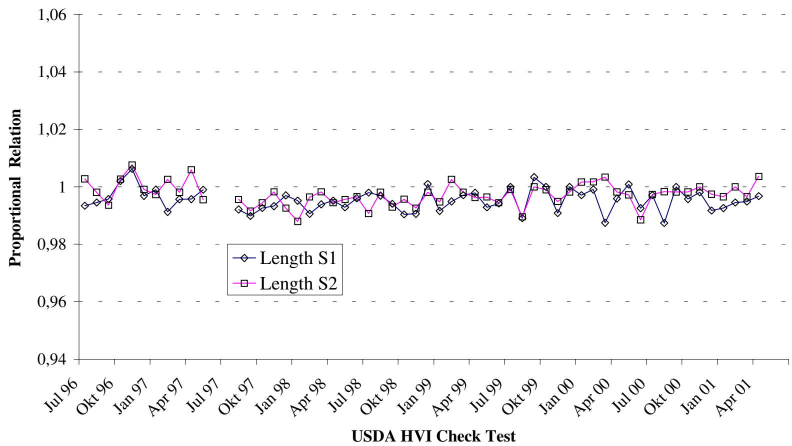

Figure 5. Bundle Length from USDA HVI Check Test (Sample 1+2).

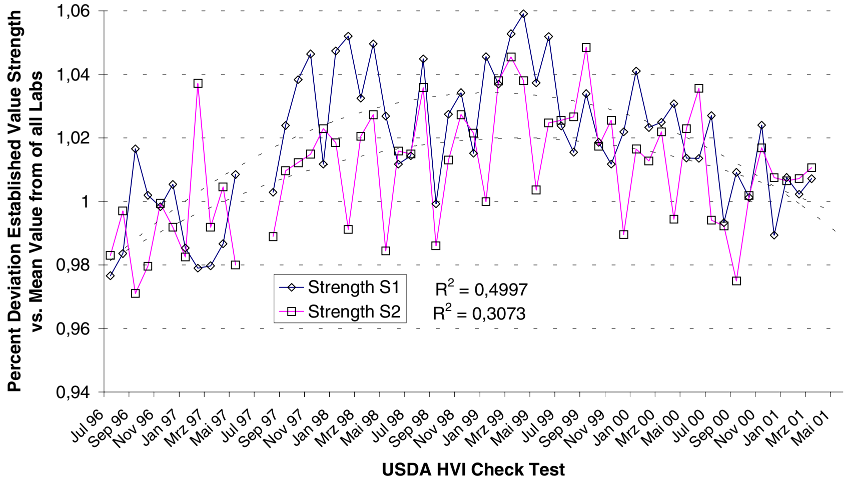

Figure 6. Bundle Strength from USDA HVI Check Test (Sample 1+2).

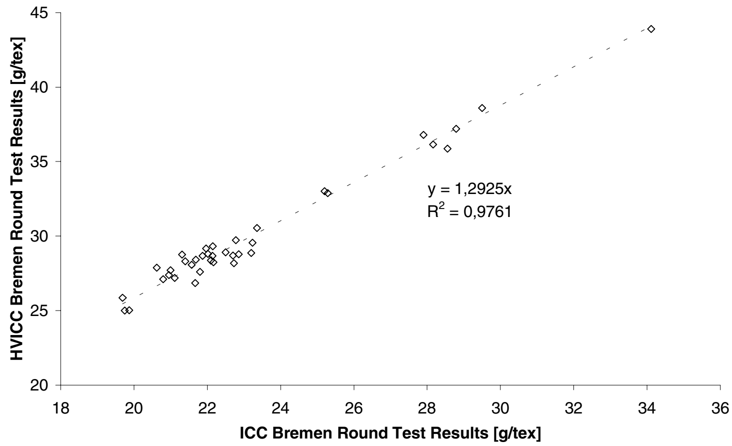

Figure 7. Cotton Round Trial Values HVICC vs. ICC.

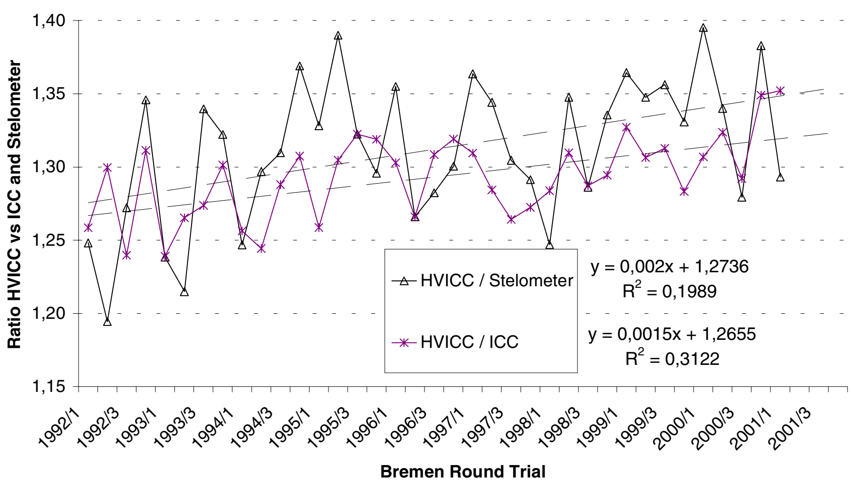

Figure 8. Change of the HVI-Level over last 10 Years.

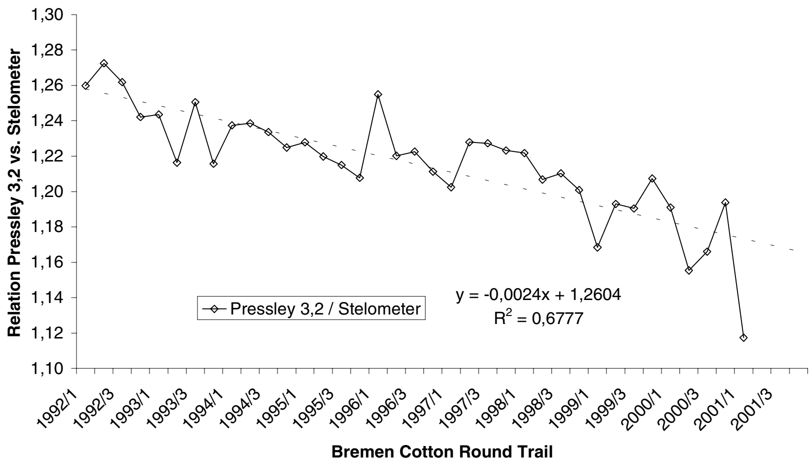

Figure 9. Pressley 3,2 vs Stelometer.

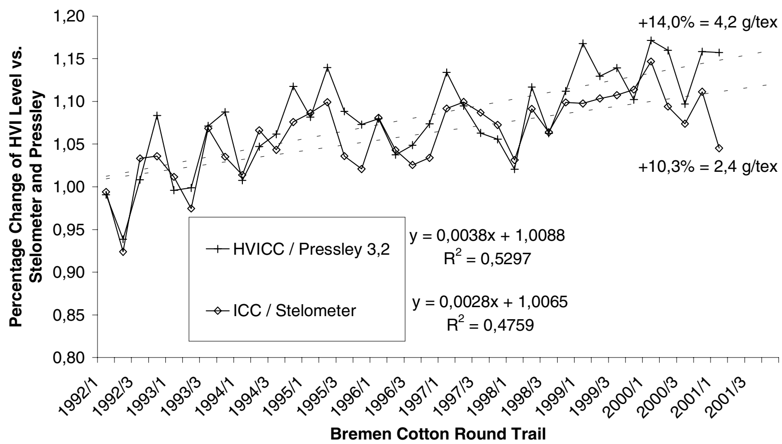

Figure 10. Trend of Cotton Base Level.