Journal of Textile Science & Engineering

Arafa, J Textile Sci Eng 2014, 4:6
DOI: 10.4172/2165-8064.1000178

Research Article Open Access

Develop and Compare New Software Based on "Lord" Equations to Calculate Fineness and Maturity Parameters by Using "HVI" Instrument

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Abstract

This present study was conducted to explore the possibility of utilizing the data of the "HVI" instrument to estimate the fiber fineness and maturity parameters of Egyptian cotton, corresponding to the same parameters provided by both of "Micro-mat" instrument and Image Analyzer. 15 of Egyptian genotypes produced by Cotton Research Institute, Giza, Egypt, as well as two of Upland cotton samples from Sudan were used in this study during the 2012 season. The samples were tested by using the HVI, Micro-mat and the Image Analyzer instruments.

Data of the degree of thickening, area of secondary cell wall, and perimeter showed that no significant difference between its means, excellent correlation and determining factor between both of the Image analysis data and the data extracted from the equation used for HVI software. Thus, it could easy to add new characters to the HVI output data and simulate both of the Micro-mat and Image analyzer instruments successfully. This equation will save time, efforts, labors and energy.

Keywords: Cotton; Fiber; Fineness; Maturity; HVI; Micro-mat

Introduction

Fineness is one of the important characters of cotton because yarn made from fine fiber is generally stronger and more uniform than yarn from coarse fibers. Also, fiber maturity is important because mature fibers has well developed cell walls, will absorb the dye better as well as less prone to cause defects of various sorts in the finished product.

Fineness and maturity can be measured in accurate way by using microscope or image analyzer [1] stated that cross sectional analysis of cotton fiber provides direct accurate measurements of fiber perimeter and maturity, which are often regarded as the reference data for validation or calibrating other indirect measurements of these important cotton fiber properties, but it is time consuming.

Thus, there is a need for an accurate and rapid method for measuring cotton fiber fineness and maturity characters. Scientists develop a lot of instruments for measuring fineness and maturity parameters, the most famous instrument is Micronaire instrument [2-4]. Micronaire measure fineness and maturity in one reading called Micronaire reading, Montalvo [5] found that Micronaire reading is an indicator of air permeability it's regarded as an indication of both fineness and maturity (degree of cell wall development),but in fact that Micronaire measurements are considerate to be a combination of fiber fineness and maturity [6].

Normal Micronaire reading don't tell us whether the fiber is coarse and immature or fine and mature. For given type of cotton fineness is genetic so, its variation is limited. A relatively low Micronaire reading has been used as a predictor of a low maturity of the same sample. Low Micronaire reading may also indicate fine fiber with adequate maturity. So, there was a need to develop new instrument for measuring fineness and maturity separately. The Micronaire tester [7] is being used to measure fineness and maturity [8,9].

The Micro-mat is a current model of a series of instruments manufactured by the company to measure fineness and maturity and generally is referred to as the fineness and maturity tester (FMT). This instrument has a double compression airflow device that measures the pressure drop of air drown through a fixed mass that is compressed, during the test to two different densities .the initial and second stage pressure drops are referred to as PL, and PH, respectively and are converted to fineness and maturity and perimeter by appropriate empirical equations [7,10]. The FMT equations were calibrate with the British Standard Methods and image analysis [11,12].

Regarding fineness, Ramey and Lord's equations could be successfully estimate all the image analyzer measurements which need time and effort [13-15] and it could be utilize easily using HVI instrument when it converted to simple software as main objective for the present study.

Materials and Methods

To estimate fiber maturity, gravimetric and intrinsic fineness measurements, by using HVI instrument. 15 of Egyptian cotton genotypes namely, (Giza 88, Giza 92, Giza 93, [G.84 (G.70xG.51b)] defined as C1, Giza 45, Giza 87, Giza 80, Giza 90, 90xAus. - defined as C2, G.83x58x G.80 defined as C3, (10229xG86) defined as C4, Giza 86, green cotton, dark brown and light brown cotton) produced by Cotton Research Institute, Giza, Egypt. As well as two upland cotton samples from Sudan were used in this study during 2012 season.

Data collection and sampling

Two maturity ratio levels were used as possible for most genotype under this study. These genotypes were used to cover the different levels for Micronaire levels and diameter values (different genotypes) to be tested for Micronaire and maturity by HVI instrument. The same specimens were tested by Micro-mat to get the Micronaire value (Mic),

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Received December 10, 2014; **Accepted** December 16, 2014; **Published** December 20, 2014

Citation: Arafa AS (2014) Develop and Compare New Software Based on "Lord" Equations to Calculate Fineness and Maturity Parameters by Using "HVI" Instrument. J Textile Sci Eng 4: 178. doi:10.4172/2165-8064.1000178

maturity ratio (MR), fineness in millitex (Fin), Ph and PL values (which refer to low and high pressure). The cross sections and the Images for the same samples were tested at the labs of Textile Consolidation Fund, Alexandria, Egypt. While, the Image Analyzer, of the Fiber Structural and Microscopic Unit Lab, Cotton Research Institute, Giza, Egypt, was used to test & analyze the images to calculate the fiber perimeter in [μ], area of secondary cell wall (ASCW) in $[\mu]^2$ and degree of thickness (θ), (Table 1). Sampling and testing were done according to ASTM 1986) and ITMF User Guide, 2001.

Statistical analysis

Firstly, data normalization test for all parameters under study were performed by SPSS software .Before T-test, all data were subjected to statistical analysis by the technique of paired T-test according to Steel [16]. Differences were considered significant at $P<0.05$. Correlation and regression analysis were computed according to Draper and Smith [17]. The data were statistically analyzed by using the computer statistical software package SPSS V.17 and for drawing diagrams, Excel software were used.

Results and Discussions

Such that Micro-mat instrument software based on the Lord's formula to calculate Micronaire, fineness and maturity readings as follows:

1-Mic= (850/PL+40) +0.6

2-MR=0.247*PL0.125 (PL/Ph) 2

3-Fin= (60000/ PL)*(Ph / PL) 1.75

Sample	Micro-mat measurement			Image analyzer measurement		
	Mic	MR	Fineness	Θ	ASCW[μ]²	P [μ]
G88 low maturity	2.8	0.79	111.62	0.47	73.01	49.01
G88 normal	3.7	0.95	137.59	0.58	98.56	49.45
G92 low maturity	2.8	0.87	105.90	0.53	73.00	47.30
G92 normal	4.0	0.99	148.89	0.60	109.62	49.32
G93 low maturity	2.2	0.75	93.00	0.45	58.28	43.00
G93 normal	3.2	0.95	114.22	0.57	83.86	44.55
C1 normal	4.2	0.98	160.57	0.57	116.21	51.05
C1 low maturity	3.3	0.90	127.74	0.53	88.14	49.11
G45	3.2	0.92	120.26	0.53	85.27	43.12
G87	3.0	0.99	103.25	0.58	79.70	42.00
G80 low	3.2	0.74	146.63	0.44	83.86	56.00
G80 normal	4.4	0.95	173.72	0.56	121.30	57.00
G90 low	3.2	0.87	127.17	0.49	85.27	54.00
G90 normal	3.8	0.94	144.02	0.54	101.66	55.05
C2	5.0	0.92	217.72	0.54	144.65	56.94
C3	4.4	0.95	176.46	0.55	123.02	56.02
G86 low maturity	3.9	0.93	153.26	0.55	106.39	52.00
G86	4.5	1.02	169.50	0.59	126.49	52.70
C4	3.9	0.92	152.32	0.54	104.80	52.41
Green	2.8	0.86	107.13	0.50	73.01	49.50
Dark brown	3.7	0.99	134.38	0.58	100.10	49.19
light brown	3.0	0.80	127.78	0.47	79.69	48.00
Upland Sudan fine	3.0	0.80	127.78	0.47	79.70	55.03
Upland Sudan coarse	4.9	0.84	231.74	0.48	140.92	67.20

Table 1: The means of reading of Fiber fineness and maturity parameters of tested samples measured by Micro-mat and Image analyzer measurements.

Sample	θ (Image)	θ (HVI)	ASCW [μ]² (Image)	ASCW [μ]² (HVI)	P [μ] (Image)	P [μ] (HVI)
G88 low maturity	0.47	0.46	73.01	71.21	49.01	45.91
G 88 normal	0.58	0.55	98.56	96.36	49.45	46.40
G92 low maturity	0.53	0.50	73.00	71.50	47.30	45.00
G 92 normal	0.60	0.57	109.62	106.62	49.32	46.19
G 93 low maturity	0.45	0.43	58.28	56.28	43.00	40.54
G 93 normal	0.57	0.55	83.86	81.36	44.55	42.45
C1 normal	0.57	0.57	116.21	114.51	51.05	49.97
c1 low maturity	0.53	0.52	88.14	86.44	49.11	46.78
G 45	0.53	0.53	85.27	83.25	43.12	41.51
G 87	0.58	0.57	79.70	87.50	42.00	39.86
G 80 low	0.44	0.43	83.86	81.36	56.00	53.86
G 80 normal	0.56	0.55	121.30	119.37	57.00	55.89
G 90 low	0.49	0.50	85.27	83.77	54.00	52.67
G 90 normal	0.54	0.54	101.66	99.66	55.05	52.43
C2	0.54	0.53	142.65	138.95	56.94	54.85
C3	0.55	0.55	123.02	121.42	56.02	53.28
G 86 low maturity	0.55	0.54	106.39	99.79	52.00	49.86
G 86	0.59	0.59	126.49	124.41	52.70	50.29
C4	0.54	0.53	104.80	98.10	52.41	49.72
Green	0.50	0.50	73.01	71.01	49.50	46.18
Dark brown	0.58	0.57	100.10	98.19	49.19	47.88
light brown	0.47	0.46	79.69	77.88	48.00	45.79
Upland Sudan fine	0.47	0.46	79.70	77.78	55.03	54.79
Upland Sudan coarse	0.48	0.48	140.92	138.62	67.20	65.62
Mean	0.53	0.52	97.27	95.22	51.21	49.07
P-value	0.663		0.233		0.275	
T- test	n.s		n.s		n.s	

Table 2: Comparison between fineness and maturity readings of tested samples obtained from image analyzer instrument and their corresponding reading calculated by using HVI instrument

According to the previous study of [18] concerning producing calibration samples for Micro-mat instrument using HVI micronaire value and maturity ratio to calculate back the PL, Ph values, which used principally to calibrate the Micro-mat instrument.

The following two equations was formed by making the PL and Ph values the main subjects for the equations numbers 1,2 mentioned before in the materials and methods:

4-PL =(1)/(mic-0.6)*(850/1)-(40)

5-Ph=SQRT (0.247*PL0.125/MR)

Thus, it could be easy to calculate fineness when the third formula is applied .The pervious study proceeded by [18] indicated the congruency of the Micro-mat fineness and calculated fineness using HVI Instrument. This because when we reversed the equations we have calculated character from accurate character (mic, MR). Thus, we add new accurate character (Fin) not predictable. This described the congruency between the fineness readings according to the pervious study.

Maturity ratio (MR %) fineness (H) were calculated from the following equation:

Maturity ratio (MR %) = $\frac{\theta}{0.577}$ ss according to [19]

= Maturity ratio x 0.577

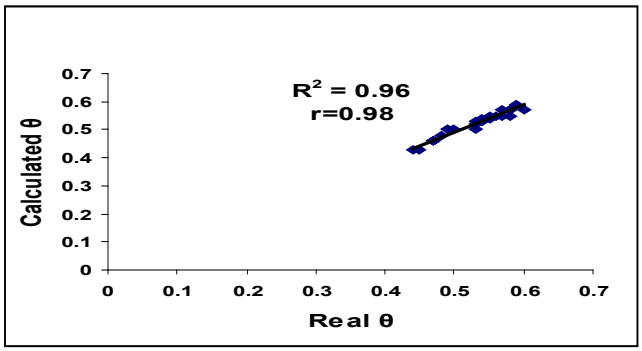

Figure 1: Comparison between degree of thickness readings obtained from image analyzer instrument and their corresponding readings calculated by using HVI instrument.

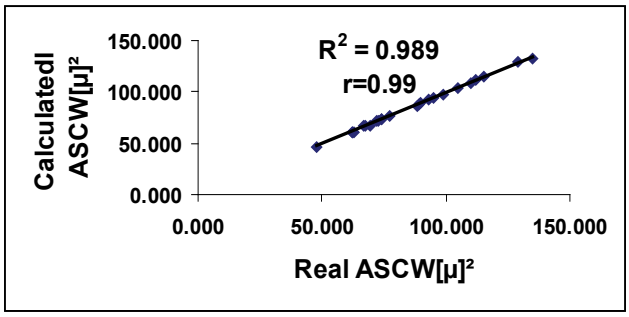

Figure 2: Comparison between area of secondary cell wall readings obtained from image analyzer instrument and their corresponding readings calculated by using HVI instrument.

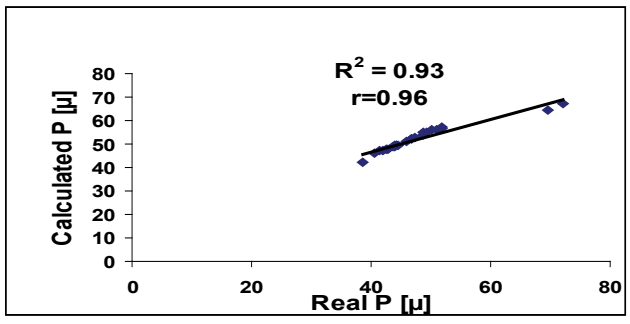

Figure 3: Comparison between perimeter readings obtained from image analyzer instrument and their corresponding readings calculated using HVI instrument.

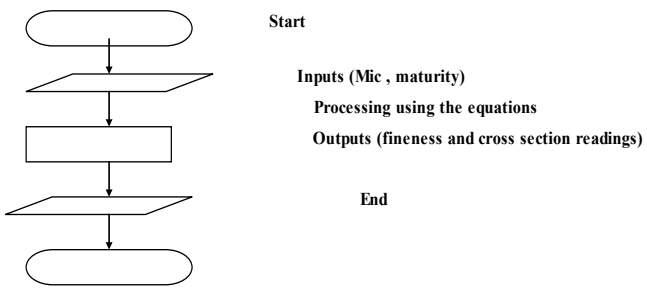

Figure 4: The software flowchart.

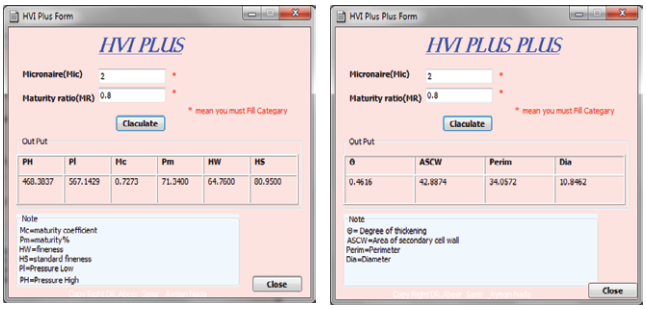

Figure 5: The software screens.

It could be calculated directly using HVI data

Fineness (Fin)=ASCW X ŋ according to [2]

Whereas ŋ=cell wall density=1.52

ASCW=Fin/ŋ

However; standard fineness (Hs) was calculated from [3] equation as follows:

Standard fineness (Hs)=Fin/MR

P=3.7853 $\sqrt{}$ Hs according to [13]

Where p=perimeter

with P=2r π, and 2r=Diameter (D). Where r=diameter

So, π X D=3.7853 $\sqrt{}$ Hs

D=3.7853$\sqrt{}$ Hs/π or D=P/π

Where, π=3.14

Diameter (D) =1.2055 $\sqrt{}$ Hs or = $\frac{perimeter}{3.14}$ [15]

Data were analyzed and summarized in Table 2. which indicated that no significant difference was observed between the means of theta obtained from Image analyzer and their corresponding values calculated by HVI Also, all the calculated data by HVI are either equal or less than those measured by HVI by 0.01-0.03 units This results explained the very high correlation r=0.98, and the excellent determination coefficient R^2=0.96 shown in Figure 1, Table 2, indicated that the area of secondary cell wall readings of Image analyzer instrument were slightly higher than that of HVI instrument. Nevertheless, the correlation and the efficient of determination between them are high, r=0.99 and R^2=0.99 as shown in Figure 2. Also the difference between the two means is within the acceptable range. Data of perimeter showed no significant difference and good correlation r=0.96, R^2=0.93 as revealed in Figure 3 between both of the Image analysis data and the data extracted from the equation used for HVI software Figures 4 and 5. The software copy-write patent were registered at smart village, Egypt under the numbers (001761/2012 and 001762/2012). Therefore, it could be successfully simulate both of the micro-mat and Image analyzer instruments and save the time, efforts, labors and energy by adding these new characters to the HVI output data.

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