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Innovative Statistical Application to Scientific & Industrial Problems for Quick and Precise Determination of Short Fiber Percentage in Cotton Textile Industry for Quality Improvement

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ABSTRACT

Today, sophisticated instruments and systems are one of any industry's most important assets to improve industrial production and economic strength. Comprehensive advanced equipment's and systems are at the foundation of every success and innovation in a wide variety of fields. With this as background, the main purpose of this paper is -

- To present that the content of short fibers in any varieties of cotton are the indigenous hazardous waste in cotton, which is the most important Fiber characteristics influencing cotton value used as raw material cost in cotton textile industry.
- However, New Proposed Developed Equation applied through Statistical Methodology for easy Industrial Implementation could reckon the content of Short Fiber Percentage (SFP) in cotton.
- Further New System defines the SFP of various numbers of mill's different cotton samples with quick and precise determination within the limit of perfection.

Thus, it helps to improve the Industrial Production and Economic Strength for Textile Industries.

KEYWORDS:SFP (Short Fiber Percentage), Count, EL (Effective Length), ML (Mean Length).

I. INTRODUCTION

What is Short Fiber Percentage (SFP)?-Presence of Short Length Fiber in Cotton, less than below norms of specified Mixing's or considered less than 12 mm in length, such length of fibers are called Short Fibers.

Even in Short Staple Cotton, there exist short fibers, which are to be considered for removal or elimination. A quantity of short fiber measures in terms of percentage from the quantum of fibers sample is expressed as percentage short fiber content.

Short Fiber Percentage (SFP) is the most important fiber characteristics influencing cotton value (used as a raw material cost), spinning performance from Blow-Room to Ring-Frame obtainable from given cotton.

Why Short Fiber should eliminate? - Amongst the fibers characteristics most of the Mills express that 2.5% Span Length or Effective Length, which should be given first priority, while 2nd priority opt for S.F.P. & fiber–fineness. Higher or lower short fiber content not only exert relatively greater influence on regularity of the Yarn but also at different stages of processing would impact on quality & working of Spinning, Weaving, Dyeing, Bleaching, Finishing as well as sales realization etc. The presence of short-fibers in Cotton Mixing leads to the formation of more short-length thick faults. In addition, the accumulated fluff on clearer pads & drafting rollers due to the presence of short-fibers in Cotton may also be getting incorporated into the yarn to form short length thick faults. Thus, to minimize short length thick faults in provided Mixing or Blending, greater attention to be paid to the opening, fibers individualization & cleaning of cotton in Blow room, Carding, Combing etc.

How SFP could helpful for managing the Short Fiber?

- More frequent cleaning of draft zone parts & better housekeeping also to be maintained knowing the content of S.F.P. would be helpful to improve quality by taking rigorous control over various settings & by prompt remedial action of mechanical defects enumerated earlier.

Further knowing of S.F.P. is necessary to keep down processing costs & also to minimize processing problems that are normally to be encountered when soft-waste or other quality of cotton added to the Mixing or Blending. Also, it would be useful to take prompt action to rectify the quality defects whenever observed.

The higher breakages, uneven yarn-quality, hairiness, low-strength tend to move up with higher S.F.P., which causes of improper selection of cotton lots for Mixing or Blending. Hence standardization of S.F.P. would be helpful in maintaining the quality with quantity of yarn under control.

However, the performance of a cotton yarn mainly depends upon cotton-properties with optimum parameters. Many properties of cotton fibers are related to its degree of S.F.P., which are alsorelated to the growing-up days after blossom of cotton, cropping, plugging, ginning etc.

OBJECTIVES

- Various Instruments and measures are available for determination of various quality parameters of cotton fibers, except the rare instruments and methods to work out the SHORT FIBER PERCENTAGE (SFP).
- Sophisticated instruments and systems, which are well developed but that cannot detect Short Fiber Percentage from the raw materials at preliminary stage of Mixing or Blending of cotton varieties.
- The Important of Short Fibers content exert relatively greater influence on the regularity of yarn and prone to higher waste generation, which would not be economical.

Existing measurement & application of SFP

- The BAER SORTER (Array) Method is generally used for the estimation of Effective Length, Mean Length, Dispersion Percentage, and Short Fiber Percentage etc. The BAER–SORTER is the only prime and precise Lab-instrument, which does Logic functions and graphically display the results.
- Another method that is used for the estimation of fiber length. It is worked out by using Auto Digital Fibrograph (ADF).
- Further in addition to the above, recently the most Sophisticated instrument namely the High-Volume Instrument (HVI) is being used forthe estimation of fiber–length.

In both ADF & HVI, the measurement process and testing sequences are automatically controlled by the Micro – Processors, which measures 2.5% span–length, 50% span–length and Uniformity - ratio percentage (UR%).

But due to the limitations of Machines, SHORT FIBER PERCENTAGE can be worked – out only by the method of Baer – Sorter except ADF and HVI, which are not useful for measuring the Short Fiber Percentage in cotton.

Flaws in prevailing method

While going through the details, though the present system is found well and good, even after some partial flaws, which are plausible to rectify.

The flaws are narrated as under –

- BAER SORTER (Array) Method is remarkable good & very accurate, but accuracy of the result is mostly based on the manual skill and expertise operating functions of the Lab-Technician, who operate or handle the BAER SORTER regularly. It requires lot of personal skill, time consuming and includes personal errors.

- Both Auto Digital Fibrograph (ADF) & High-Volume Instrument (HVI) are the most sophisticated instruments, but due the limitations of machines, Short Fiber Percentage (SFP) cannot be worked out.

The Accuracy factor from data sources will vary on prior evaluation based on accepted criteria. Also while collecting the primary and their Updation by different methods from different people, the consistency and concurrency factors will be taken care of. However, there is need for uniform guidelines, policies and an action plan for evaluating and building databases, which will facilitate integration of databases for utilization by specific target groups.

II. INVENTION BASE

Prime Base- Short Fiber Percentage (S.F.P.) being worked-out by Baer-Sorter a Lab-Instrument, which has become dates back to nineteenth century and despite the limitations of other equipment's, it is not possible to estimate SFP, but same is desirable to determine from the FIBER properties of 2.5% Span-Length, 5o% Span-Length and Uniformity Index Percentage (U.I.%) which are worked-out by ADF (Auto Digital Fibrograph) or High-Volume Instrument (HVI) etc. S.F.P. can be computed in two ways. A significant introduction, which includes the proposed methods adopted for the following. Further Statistical Decision Theory provides a basis for solving a search problem through a SIMULATION, which are not only associated with collecting & analyzing data to reduce decision errors but also easy to solve them scientifically by mathematical sophistication of the analyst.

III. INVENTION BASE METHODOLOGY

Methods of Determination of SFP

1. Determination by new proposed developed equation:

(A) For 50 % Span length is less than 12 mm –

S.F.P. = [50% S.L. + ⚜] x<u>U. I.%</u>

⚜

Where **⚜ = 6,**

⚜ = 48% are the constant factor.

(B) For 50% Span length is at 12 mm and above –

S.F.P. = [50% S.L. + ⚜] x <u>⚜</u>

⚜

Where**⚜ = 6, ⚜ = 48%, ⚜ =<u>U.I.%</u> = 1200**

2.5 % S.L.

are the constant factor

2. Determination by new proposed graphic system:

(A) S.F.P = Length of short fibers spread-up on X-Axis in Cms x 100

Length of X-Axis in Cms

(B) i- X-Axis in Cms =◎ x 2.5% S.L. in mm

ii-Y-Axis in mm =◎ x 2.5% S.L. in mm

iii- Length of short fibers spread up on X-Axis = X-Axis – [◎ x 2.5% S.L. (100- U.I.% x◎)]

iv- Effective Length = <u>Y -Axis in mm</u>

◎

v-Mean Length =<u>Effective Length</u> (U. I.% +◎)

2

Where**⚜ = 0.78, ⚜ = 1.27, ⚜ = 0.007, ⚜ = 0.20, ⚜ = 1.11, ⚜ = 1** are the constant factors.

3. Functional illustration by example- A Cotton sample as an example is considered for application along-with functional illustration by New Proposed Developed Equation and Graphic System as under and compared with the testing results gained by actual Mill's Lab-instrument.

Details of Example

Mixing	Quality of Cotton	Span Length		U.I.%	Remarks
		2.5%	50%		
20s	NHH – 44	24.50	* 11.30	46%	* 50% S.L. is less than 12 mm.

The procedure of the study is given in details under each sub-topic.

Illustration by example

Determination by new proposed developed equation -

In this example, 50% S.L. is less than 12 mm. Hence it is worked out by two ways –

i 50% S.L. less than 12 mm.

ii 50% S.L. 12 mm and above.

a) For 50 % Span length is less than 12 mm –

S.F.P. = [50% S.L. +⚜] x <u>U. I.%</u>

⚜

✥

Where✥ = 6,✥ =48% are the constant factor.

= [11.30 + 6]46% = 17.30 x 0.46 = 16.58%

48% 0.48

b) SFP to be worked out at 12 mm and above, Where 50% Span length less than 12 mm of the sample –

S.F.P. = [50% S.L. +◎] ◎

◎

Where✥= 6,✥= 48%,✥ =U.I.% = 1200

2.5 % S.L.

are the constant factor.

✥= U.I.% = 1200 1200

----------- = ------------ = 49%

2.5 % S.L. 24.50

Therefore,

S.F.P. = [50% S.L. +◎] ◎= [12 + 6] 49%

◎ 48%

= 18.38%

Determination by new proposed graphic system

[Note- If 50% S.L. is less than 12 mm, here is no provision in Baer-Sorter System to work-out S.F.P. for 12 mm and above 50% S.L.]

a) Prior to work-out S.F.P., X-Axis, Length of Short-Fibers Spread-up on X-Axis are required to be known.

Following are worked-out, where 50% S.L. is less than 12 mm of the sample.

i X-Axis in Cms = ◎ x 2.5% S.L. in mm

= 0.78 x 24.50 = 19.11 Cms.

ii Y-Axis in mm = ◎ x 2.5% S.L.

= 1.27 x 24.50 = 31.12 mm.

iiiLength of Short Fibers Spread up on X-Axis

(Where 50% S.L. is less than 12 mm)

= X-Axis – [◎ x 2.5% S.L. (100 U. I.% x◎)]

= 19.11 – [0.007 x 24.50 (100 – 46% x 0.20)].

= 19.11 - [0.007 x 24.50 (100 – 46 x 0.20)]

= 3.54 Cms.

iv Short-Fiber Percentage

= Length of Short-Fibers Spread-up on X-Axis in Cms x 100

Length of X-Axis inCms

= a – iii x 100 = 3.54 x 100 = 18.52%.

a – i 19.11

vEffective Length in mm

= Y-Axis in mm = a - ii = 31.12 = 28.04 mm

◎ 1.11 1.11

vi Mean Length in mm

= Effective Length(U. I.% +◎)

2

= a – v (46% + 1) = 28.04 (0.46 + 1)

2 2

= 14.02 x 1.46= 20.47 mm.

b) Calculations are worked-out for 50% S.L. is at 12 mm and above. Where UI.% is available only for less than 12 mm (50% S.L.).

i X-Axis in Cms = Same As a-i = 19.11 Cms.

ii Y-Axis in mm = Same As a-ii = 31.12 mm.

iiiLength of Short Fibers Spread-up on X-Axis

= X-Axis – [◎ x 2.5% S.L.(100 U.I.% x◎)].

(Where U.I.% for 12 mm and above will be as –

= ◎ ◎ ◎ ◎1200 = 1200 = 49%

2.5% S.L. 24.50

Hence, X-Axis – [◎ x 24.50 (100 49% x◎)]

= 19.11 – [0.007 x 24.50 x 90.20]

= 19.11 – 15.47 = 3.64.

iv S.F.P.

= Length of Short Fibers Spread-up on X-Axis in Cms x 100

Length of X-Axis in Cms.

= b-iii x 100 = 3.64 x 100 = 19.05%.

b -i 19.11

v Effective Length in mm

= Same As a-v = 28.04 mm.

vi Mean Length in mm

= Effective Length x (U.I.%. +◎)
2

= b-v x (49% + 1) = 28.04 x 1.49
2

= 20.89 mm.

Determination by a lab-instrument named Baer-Sorter- A Sample of Cotton given in Example-A, randomly selected from the Lot, mixed, combed and sorted manually in a proper way through Baer-Sorter and then fibers are aligned on Velvet-Board in descending order i.e., from higher FIBER-length to lower fiber-length. After the alignment is over, graph is sketched from the Velvet-Board on a graph paper by keeping the piece of glass on Velvet-Board.

To Calculate X-Axis, Y-Axis, Length of Short-Fibers Spread-up on X-Axis, S.F.P., Effective Length, Mean Length etc. according to the Lab'sPrescribed method (Baer-Sorter Method), consider the following example (please refer Graph No. 1).

1. Consider **OA** and **OB** are X-Axis and Y-Axis, where **OA = 19.20 cm** and **OB = 31.12 mm.**
2. **Q** is the mid-point of OB i.e.,**OQ = ½ OB**.
3. From **Q**, draw **QP^I** parallel **OA** to cut the curve at **P^I**.
4. Draw the perpendicular **P^IP**.
5. Mark **OK** = ¼ **OP** and erect perpendicular **K^IK**.
6. **S** is the mid point of **K^IK**.
7. From **S,** draw **SR^I** parallel to **OA** to cut the curve at **R^I**.
8. Now draw the perpendicular **R^IR**.
9. Mark of **OL** = ¼ **OR**.
10. Erect the perpendicular **L^IL,** which is **Effective Length**.
11. **E.L = L^IL = 28.5 mm**
12. **Length of Short-Fiber Spread-up on X-Axis = 3.6 cm.**
13. **S.F.P. = RA x 100 = 3.6 x 100 = 18.75 = 18.8%.**
OA 19.2
14. **Mean Length = 21 mm.**

Y-Axis	X–Axis	Cumulative	Product of X & Y Coll.
30	26	26	780
28	23	49	644
26	26	75	676
24	17	92	408
22	23	115	506
20	12	127	240
19	13	140	234
16	10	150	160
14	9	159	126
12	8	167	96
10	6	173	60
8	4	177	32
6	7	184	42
4	5	189	20
2	3	192	6
Total		**192 mm**	**4030**
Mean Length = 4030 / 192 = 21mm			

Inference of example- Under the reference of the above for comparative purposes, all the test results worked out by New Proposed Developed Equation and Graphic Method as well as Lab-Test- Equipment are summarized and analyzed. Please refer the following Table No. 1

Sr. No.	Parameters	Results Achieved By		
		Developed Equation	Graphic System	Baer Sorter
1.	X-Axis	-	19.11 cm	19.20 cm
2.	Y-Axis	-	31.12 mm	31.12 mm
3.	Short-Fibers Spread-up on X-Axis			
	i – Less than 12 mm.	-	3.54 cm	3.6 cm
	ii – 12 mm and above.	-	3.64 cm	
4.	S.F.P.			
	I – 50% S.L. less than 12 mm.	16.58%	18.5%	18.8%
	ii – 50% S.L. 12 mm and above.	18.38%	19.05%	
5.	Effective Length	-	28.04 mm	28.5 mm
6.	Mean Length			
	I - 50% S.L. less than 12 mm.	-	20.47 mm	21 mm
	ii - 50% S.L. 12 mm and above.	-	20.89 mm	

Table 1.1

Experimental results from Table No. 1 monitor & reveal that it is quite possible from both the systems to calculate S.F.P., X-Axis, Y-Axis, Length of Short-Fiber Spread-up on X-Axis, E.L & M.L. etc. which are closely correlate with the results of Baer-Sorter. The relation among New Developed Equation/Graphic System and Lab-Instrument variables are very complex and totally match with the actual results tested in Laboratory.

Illustration by graphic means of above example- Conclusion may be summarized from the results obtained in the investigation carried out to study the effect of measures by comparing with the actual Lab-test results. Figure 1 is drawn with the results obtained from above Example

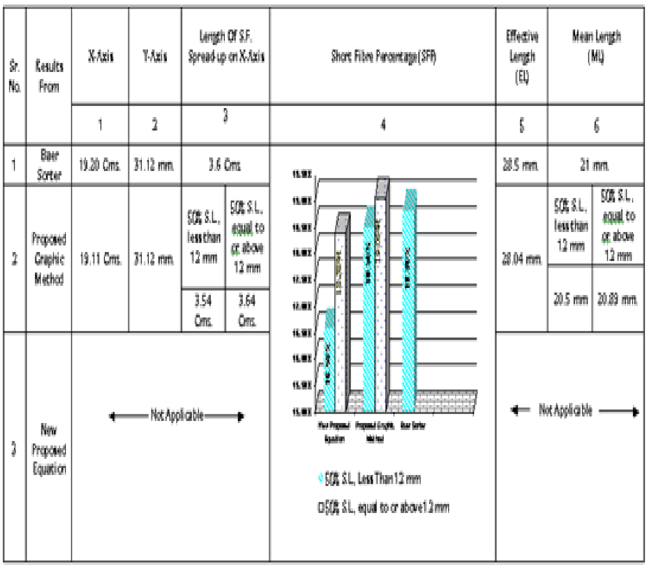
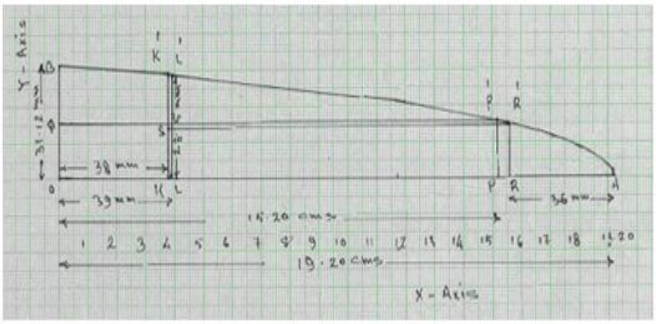


Figure 1



Graph 1

It will be found from the Figure No. 1 that on-line information results provided by both the proposed method & system exactly correlates with a very large proportion as the quality control Lab requirements.

However, the investigations carried out with a simple & faster programme have revealed that both the New Equation and System play an important role for quality elevation to achieve the perfect results as compared to the actual measures tested by Baer-Sorter

IV. SALIENT FEATURES

Reliability and Quality Assurance-New Proposed Method & Systems are both on line monitoring system to provide an early indication of changes at predetermined stage in the process, while the following extensive measures & procedures use in practice to avoid common process disturbance such as dirt, wear defects and unavoidable operational faults, suffer from some basic inadequacies like non consideration of the end-use factor, infrequent Updation, biased sampling etc., which start up from beginning of the production.

Extensive Measures

1. Random sample inspection of raw material.
2. Start up Control.
3. Monitoring of Machine function.
4. Preventive clearing.
5. Major & minor maintenance program.
6. Quality Judgment for programming from wide material ranges etc.

Main Features- The old prevailing systems can be replaced by the New Proposed system, as the old system is time consuming, needs personal skills, gets wrong results due to the personal errors, etc, as well as other sophisticated instruments (i.e., ADF,HVI, and others) have the disability to measure the same. Further new proposed system is better as compared to the old existing systems because of the following reasons –

1. It is not dependent to a high degree on the investment in time and efforts during the initiation phase.
2. Great progress can be achieved, because of the process optimization and improvements to the organizations. Therefore, the investments in on-line monitoring by new measuring systems can be significant economic advantages.
3. It provides for implementing strategies to improve the manufacturing process to motivate all the employees towards achieving the corporate objectives.
4. Also, the end-use requirement and international quality standards can be achieved while specifying the required quality.

Besides, several quality standards are available in the form of survey-results, statistics, and institutional norms etc. However the negative trend of the old prevailing systems reflects the norms of standard, which suffer due to some basic inadequacies.

The New Proposed Method & System overcome such deficiencies before the start of the process at Mixing / Blending in Spinning and call for a fresh look at the real usefulness of measurement & application of Short Fiber Percentage (SFP), Effective Length (EL), Mean Length (ML), etc., attract the attention, which include the following –

1. The concept of diagnosing the SFP, EL and ML can equips everywhere in Cotton Textile with its own network, as it plays a key role in the improvement of competitiveness.
2. It is a self-diagnosing system to know the S.F.P. of available Cotton samples or Cotton lots before the start of Mixing Process at Spinning.
3. More economy & ecology as well as low operating cost.
4. Measuring system with low mass & little processing nature.
5. Final product can meet with highest demands.
6. Incorporate cost reductions attributable to value engineering in profit planning & ensure achievements.

V. CONCLUSION

In conclusion, it can be stated that while striving to achieve international level quality standards for yarn delivered to the market, the New Proposed Systems are extremely useful as a Bench-Marketing Tool for any product category of Cotton to attribute the results accurately. Further, to enhance quality out-put with low-mass & facilitate rapid transfer to the market place, also promotes competitive & substantial growth preservation of the eco-system (energy saving & environmental protection.).

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