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Effect of Cotton Fibers and Their Trash Characteristics on the Performance of Spinning Preparatory Processes

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ABSTRACT
Technological revolution in the age old cotton textile industry has made spinning preparatory section as a control centre for quality and economy of the outgoing product. Spinners have to chase these goals by cleaning the cotton mix without detoriating feed cotton characteristics and undue increase in the waste levels at higher productivity level. The successful efforts demand through investigation of the cotton fibers and their trash characteristics as well as identification of their best fit interrelationship with process parameters. Set of experimentations done in this direction are described in this paper as case study.
Keywords: Trash, Blow room, UQL, Neps, Card, Waste.

I. INTRODUCTION

Production of good quality yarn demands high degree of opening and cleaning at the spinning preparatory stage, but how this opening occurs is also equally important. Response of various types of cotton against the mechanical treatments given by blow room machines (beaters) and card, for the removal of trashy matter is different[1-3].Mechanical damages: fiber rupture (increased short fiber generation) & nep formation, and thereby reduced UQL(w) and increased waste level on carding are the major set-backs for higher operational speed in this regards. These enforces to work at lower beater speeds and wider grid bar settings, although it results in higher lint loss. Best fit process parameters can be judged by a set of experimental trials only.

II. EXPERIMENTAL WORK

While working with trashy cotton, mill usually takes the stand to work with lesser cleaning efficiency at blow room to prevent fiber damage and higher lint loss. This is mainly aimed to translate good but costly fiber characteristics into desired R_{km} of yarn. But this adds to the work done at the card and its influence on the card sliver quality, cost and card waste level becomes interesting to be investigated. The present paper describes the study done in this direction.

2.1 Materials

Cotton mix formulated from 65% DCH-32 and 35 % MCU-5 cotton was used for the study. The selection of mix components and their proportion was abide by the mill practices for spinning 80^{s} Ne combed ring spun yarn.

2.2 Methods

Rieter's blow room and card machine sequence, viz;Unifloc B12- Uniclean B11 – Unimix B60 – Uniflex B70 – Vision Shield FFD – Condensor A21 and Card C 60 were used for this purpose. Mill was operating at 30 kg/hr card production rate with 99.00 % combined blow room and card cleaning efficiency for 5.71 % trash content of input cotton mix to meet customer's demand.

Both the openers in the blow room, viz; Uniclean and Uniflex, are operating under 'Varioset Cleaning Field'. Thus, with only two settings; Cleaning Intensity (CI) and Relative Amount of Waste (RAW), entire cleaning process can be changed from gentle to intensive [4].Accordingly the blow room set up cleaning action was altered and its effect on card sliver performance was studied.

Cleaning Intensity and Beater speed is directly proportional. So, working with higher Cleaning Intensity can increase the fiber opening and thereby trash removal from feed cotton. At the same time higher beater speed also increases fiber stress, especially in case of longer, finer, cohesive but trashier DCH-32 in the mix. This can lead to excessive fiber rupture and nep formation [5,6]. Thereby Uniclean CI was set at 0.4 (635 rpm), within the suggested range for cotton having trash within 3 to 6 percent range [4]. Higher opening is recommended at pre-cleaner than fine cleaner. So, in order to avoid finer fiber damage, Uniflex was set just at a minimum possible beater speed, i.e. CI of 0.0 (340 rpm), throughout the study.

Relative Amount of Waste (RAW) is directly proportional to the grid bar angle. Higher the angle, wider will be the setting and correspondingly more waste gets extracted and vice versa [4]. Two different values of RAW (influencing grid bar angle) were chosen for each beater to achieve desired degree of cleaning (table 1). Three trials each with one hour running time were conducted, after cleaning entire waste line of the spinning preparatory. Cotton samples from input and output end of each blow room opening machine and card were collected for checking various fiber parameters in order to define fiber damage and machine cleaning efficiency. Cleaning efficiency of the machine is defined as per equation 1.

$$\%\ \text{Cleaning Efficiency} = \frac{\%\ \text{Trash in feed} - \%\ \text{Trash in delivery}}{\%\ \text{Trash in feed}} \times 100 \ldots\ldots \text{equation1}$$

Similarly waste from each cleaning point was collected for its trash analysis and lint characteristic study.

Table 1: Experimental Set up

Sample code	Machine type	Varioset Cleaning Settings	
		RAW	CI
1	Uniclean	5	0.4
	Uniflex	3	0.0
2	Uniclean	6	0.4
	Uniflex	3	0.0
3	Uniclean	5	0.4
	Uniflex	5	0.0

III. RESULTS& DISCUSSION

3.1 Cotton Fibers and their mix Properties:

HVI test results for individual cotton and their mix (sample collected from lay down) are given in table 2.

Table 2: HVI Test Results

Sr. No.	Properties	DCH-32	MCU-5	Cotton Mix (65% DCH-32 + 35 % MCU-5)
1	Micronaire(µg/inch)	3.31	3.85	3.54
2	Strength (gf/tex)	34.60	32.55	33.73
3	UHML (mm)	33.69	30.08	32.16
4	Uniformity Index	86.27	85.60	85.99
5	SFI	4.67	5.15	4.87
6	Elongation (%)	5.23	4.70	4.23
7	Maturity Ratio	0.84	0.86	0.85
8	Rd value (%)	70.4	80.50	74.74
9	Plus b	11.4	9.90	10.77
10	Trash (%)	6.20	3.00	5.72

It is apparent from the test results that two cottons mixed together were critically different than suggested SITRA standards [4] in terms of their major properties, viz; Micronaire (15.08 % against 6 %), UHML (11.32 % against 4 %), strength (6.10 % against 5 %) and trash content (69.57 % against 7 %). Although critically different, the basic aim of mill behind this combination was to control higher cohesiveness (stickiness) of long staple (34 mm) DCH-32, used in mix for attaining desired yarn strength (Rkm) for spinning finer 80^{s}C ring spun yarn.

3.2 Cleaning Performance of Blow room and Card

Cleaning performance of blow room and Card was analyzed on the basis of trash and fiber damage analysis done for cotton samples withdrawn at various stages in all the trials.

3.2.1 Trial 1: Micro Dust Trash Analysis (MDTA) results for the first trial are reported in table 3.

Table 3: MDTA test results

Trial 1: Uniclean: RAW =5, CI = 0.4 & Uniflex: RAW = 3, CI = 0.0						
	Lint	Seed Coats%	Trash%	Micro Dust%	Total Trash%	Cage Lose%
Lay down	92.5	3.28	2.33	0.11	5.72	1.78
Unifloc output	--	--	--	--	--	--
Uniclean output	95	2.221	0.247	0.051	2.52	2.481
Unimix output	--	--	--	--	--	--
Uniflex output	97.5	1.79	0.43	0.06	2.28	0.22
Chute feed	96.5	1.82	0.48	0.05	2.35	1.15
Sliver	99	0	0.024	0.027	0.051	0.949
Blow room C.E. (%) = 58.91						
Combined CE (%) of Blow room & Card = 99.10						

It is apparent that the desired degree of sliver cleanliness was achieved at 99.10% combined cleaning efficiency of blow room and card. Blowroom had contributed 58.91% cleaning efficiency against the suggested minimum standard of 65%, given for the cotton with total impurities ranges between 4-8%, by industrial standards [9]. Looking at the distribution of cleaning efforts between two beaters of blow room, major share was borne by Uniclean (55.95%) as compared to Uniflex (6.75%). This was mainly attributed to lowest CI (0.0) set at Uniflex. This had not allowed the fine beater to operate at high speed, resulting in lesser degree of opening and thereby lesser cleaning achieved at Uniflex (Figure 1).

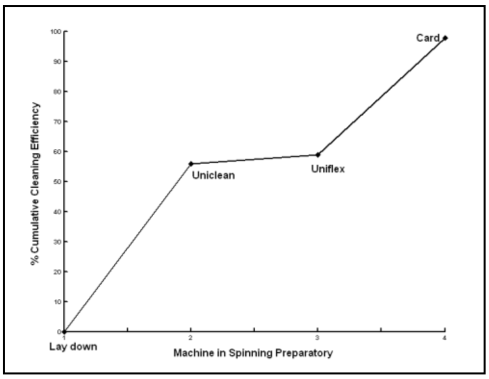

Figure 1: Cleaning Performance at various stages of spinning preparatory for first trial

The argument has also got support from the low blow room droppings (= 5.44%) than the suggested standard (6.21% = Trash (%) in mix + 0.5%) for the selected mix trash level [7]. This behaviour was mainly due to difficulty of this mix against opening. Long, fine and highly cohesive nature DCH-32 cotton fibers, which were embedded with higher trash, offered higher resistance against opening. It had prevented blow room machines to put higher efforts in removing trash from the cotton, otherwise leading to increased fiber damage.

The samples were also checked for the change in fiber properties at each processing stage and test results are reported in table 4.

Table 4: Change in Fiber Properties at Each Processing Stage of Spinning Preparatory
[Trial 1: Uniclean: RAW =5, CI = 0.4 & Uniflex: RAW = 3, CI = 0.0]

	Micronaire	Mat	UHML (mm)	UI (%)	SFI (%)	Str (gf/tex)	Elg. (%)	Rd (%)	Plus b
Laydown	3.50	0.80	32.20	86.0	4.9	33.7	4.2	74.7	10.8
Unifloc output	3.43	0.84	33.37	85.1	5.0	33.6	4.4	71.3	10.8
UNICLEAN output	3.54	0.86	32.13	81.0	5.7	32.8	5.0	70.4	12.2
Unimix output	3.23	0.83	32.47	82.8	5.3	34.3	5.0	70.7	11.8
Uniflex output	3.25	0.84	31.96	83.2	5.6	33.5	4.9	72.2	11.4
Chute feed	3.20	0.83	31.86	82.7	5.7	33.8	4.8	70.2	12.0
Sliver	3.25	0.83	29.95	82.2	6.0	33.7	4.7	75.6	11.8

It is apparent that the reduced efforts put up by the blow room had overburdened card in removing the trash. Higher mechanical stresses induced at card had resulted in increased short fiber content (From 4.9 % to 6 %) and thereby reduced UHML and UI in card sliver as measured by HVI (table 5). Change in UHML: 29.95 mm from 32.20 mm of raw (lay down) cotton. The same has dropped UI from 86.0% in raw cotton to 82.2% in card sliver.

Even higher card waste (8.48%) was extracted to attain desired 0.05% residual trash in card sliver. This higher waste extraction was done at the cost of higher good fiber loss in card waste. HVI analysis of lint loss in the card waste has substantiated the argument. The HVI analysis of the lint in card waste had shown higher good fiber loss. This had been reflected in terms of higher UHML at each waste extraction point in card; 26.62 mm in licker -in box waste, 29.49 mm in Licker-in hood waste and 27.39 mm in flat waste(table 5).

Table 5: HVI Analysis of Lint loss in various stages of Spinning Preparatory Waste
[Trial 1: Uniclean: RAW =5, CI = 0.4 & Uniflex: RAW = 3, CI = 0.0]

Waste / stage	Micronaire	Mat	UHML (mm)	UI (%)	SFI (%)	Str (gf/tex)	Elg. (%)	Rd (%)	Plus b
Uniclean	2.79	0.79	26.03	74.3	10.3	28	4.4	--	--
Uniflex	2.69	0.78	24.89	73.5	11.9	25.9	5.2	--	--
Licker-In (Box)	2.97	0.79	26.62	72.8	11.9	26.9	5.2	63.6	13.4
Licker-In (Hood)	2.41	0.77	29.49	78.6	7.5	28.4	4.4	65.3	12.8
Flat	3.42	0.82	27.39	77.3	8.9	29	5	65.7	13.1

3.2.2 Trial 2:

It is not possible to increase beater speed (Cleaning Intensity) at either of the beating point in blowroom, as mentioned in previous section. So, efforts were put to reduce card load by extracting more waste at Uniclean in second trial (table 1) by keeping rest of the blow room machine settings constant, only RAW of Uniclean was increased from 5 to 6. Increased Uniclean droppings had not shown any improvement in blow room cleaning efficiency, on the contrary reduced it. Total trash extracted in droppings (Uniclean waste) was reduced from 80.66% to 70.19% along with rise in lint loss from 17.22% to 26% with wider grid bar settings, table 6. Apart from that, for the constant beater speed, fiber damage remained unaltered, viz; reduced card sliver UHML and UI as compared to fed raw cotton values.

Table 6: MDTA Analysis for Blow room Waste with different RAW settings at Uniclean:

Waste / stage	Lint (%)	Seed coats (%)	Trash (%)	Micro dust	Total trash (%)	Cage loss
Uniclean RAW=5	17.22	67.29	13.17	0.196	80.656	2.124
Uniclean RAW=6	26	51.74	18.368	0.075	70.183	3.817

3.2.3 Trial 3:

Third trial was conducted by increasing RAW value of Uniflex from 3 to 5 by retaining rest of the settings as per first trial [table 1].Wider grid bar settings used at fine cleaner point had exceeded total waste from 13.90% to 14.44 %. This rise was incurred at the cost of good fiber loss as per expectation. Higher lint loss (35% from 11.63%) was found in Uniflex droppings (waste) at the time of MDTA analysis, but this increased waste had not shown any beneficiary effect on total trash extracted in this waste. On the contrary total trash in waste got reduced. The reduction in total trash had happened at the cost of reduced seed coats and micro dust extraction (table 7), adding workload on the card, especially in terms of higher seed coat removal.

Table 7: MDTA Analysis for Blow room Waste with different RAW settings at Uniflex:

Waste / stage	Lint (%)	Seed coats (%)	Trash (%)	Micro dust	Total trash (%)	Cage loss
Uniflex (RAW=3)	11.63	73.12	12.52	0.178	85.818	2.552
Uniflex (RAW=5)	35	47.586	14.301	0.147	62.034	2.966

This was reflected in card sliver which had shown an increase in neps and seed coat nep formation (Figure 2).Thus for identical Uniclean performance, wider grid bar settings used at Uniflex had not only deteriorated blow room cleaning performance but importantly card sliver quality.

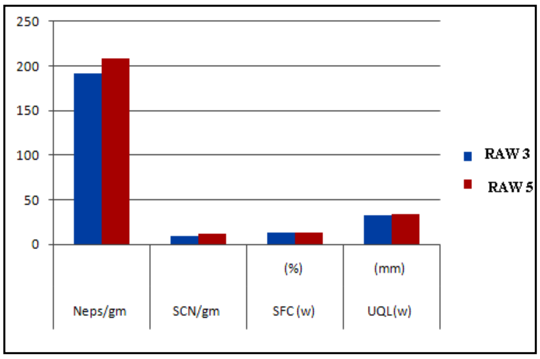

Figure 2: Comparative AFIS Analysis for Card Sliver

IV. CONCLUSION

Trashy but difficult-to-clean category of fiber mix was processed on Rieter's spinning line for producing fine combed ring spun yarn (80s Ne). Long, fine and cohesive DCH-32 fibers have shown difficulties in opening and did not allow blow room to work intensively to clean higher trash laden mix. Card was bound to work more to get desired degree of cleanliness. Keeping least fiber damage and good fiber loss as basic criteria, required cleaning performance was best attained with first combination (Uniclean: CI = 0.4, RAW = 5, Uniflex: CI = 0.0, RAW = 0.0.

The efforts were also made to increase blow room cleaning efficiency by increasing the Relative Amount of Waste at Uniclean as well as Uniflex. They had resulted in increased good fiber loss and neps in card sliver. The situation met was totally undesirable for combed variety as it increased waste level not only at blow room but at upcoming comber alsodue to presence of higher neps & Short fibre content in card sliver. All together will affect yarn realization adversely. It is a proven fact that lower the yarn realization, higher will be the yarn cost per Kg and result into uneconomical consequences.

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