STUDY ON IMPROVEMENT OF BLOW-ROOM PERFORMANCE

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Key Words

Blow room; Cleaning efficiency; Experimentation; Beating points.

Introduction

In a typical spinning mill producing cotton yarn from raw cotton, the blow room is the first of several stages of operation. The blow room is meant for opening raw cotton and cleaning it of trash, foreign matters, and so forth. The performance of the blow room in terms of cleaning plays a vital role in the determination of yarn quality. This performance is measured quantitatively using an index called the cleaning efficiency (CE) expressed in percentage (%). CE is the ratio of trash removed in the blow room to the trash content in raw cotton, that is,

$$\text{Cleaning efficiency} = \frac{\text{Trash in feed (\%)} - \text{Trash in delivery (\%)}}{\text{Trash in delivery (\%)}} \times 100. \quad (1)$$

The cleaning efficiency of the blow room depends on the amount of trash content, short fiber content in raw cotton, and the number of beating points used. In the blow room, cotton is opened and cleaned continuously at every beating point. Ultimately, processed cotton goes out of the blow room in the form of lap for the subsequent carding operation. The CE at the individual beating points is calculated occasionally for control purposes; the CE of the blow room, which measures its overall performance, is calculated regularly.

Attaining proper cleaning efficiency at blow room ensures the following:

(i) Less trash content and better opening in the laps
(ii) Proper functioning of the next process (i.e., carding)
(iii) Fewer yarn imperfections and better yarn appearance

Problem

The industrial standard for the CE is minimum 65% when the raw cotton contains impurity in the range 4–8%. The mill receives raw cotton with impurity in this range, but the achieved CE was only 49% on the average, which was quite low.

It is well known that the cleaning efficiency can be improved by increasing the number of beating points. However, with an increased number of beating points, fiber rupture takes place, resulting in poor yarn quality. In this connection, the number of beating points is predetermined for cotton of any particular impurity level. Thus, increasing the CE by increasing the number of beating points is completely ruled out.

Therefore, the problem was to improve the cleaning efficiency of the blow room, with the standard number of beating points. A study was planned.

Objective

The objectives of this study were as follows:

(i) To examine the scope of improvement of cleaning efficiency of the blow room
(ii) To suggest remedial measures for improvement

Approach

With the above objectives in mind, the steps were as follows:

(i) Process study
(ii) Data collection and analysis
(iii) Experimentation
  Factor and level selection
  Designing the experiment
  Conducting the experiment
(iv) Analysis
(v) Inference and deciding remedial measures
(vi) Implementation of remedies
(vii) Conclusion

Process Study

Cotton in the blow room is opened and cleaned continuously in a sequence through all the beating points. The schematic diagram of the operations of a particular line is given in Figure 1.

The MBD opener is the first beating point, where raw cotton from mixing is opened and cleaned. Subsequently, the output of the beating point is delivered to the next beating point, the Mono cylinder, and similar operations are performed. This continues until the cotton passes through all the stages and through all the prescribed beating points.

It must be noted that overall CE is the cumulative effect of all the prescribed beating points. The CE of an individual beating point, in turn, depends on the type of beating point and the process parameters, namely setting, feed, and speed.

Data Collection and Analysis

Because the individual beating points decide the performance of the blow room, it is necessary to judge the performance of each beating point. For this purpose, blow room line 5 (which is used regularly) was selected.

Corresponding to each beating point, samples were drawn from its input as well as output. It should be noted that output of any beating point is input to the immediate next beating point.

For each sample (whether input or output), essentially a composite one, weighing approximately 100 g of cotton was collected. This composite sample was prepared based on three to four random samples covering the whole area of the feeding zone. Subsequently, the sample was analyzed for trash% using the Shirley Analyser, and the CE of the concerned beating point was calculated using Eq. (1). This was done for all the beating points.

The cleaning efficiencies thus calculated at various beating points are presented in Table 1. The last column in the table gives the standard CE value corresponding to each beating point.

It was concluded from Table 1 that cleaning efficiency was low at the ERM opener, Mono cylinder, and Krishner beater II compared to industry norm. However, the performance of the beating points will be clearer if we compare the stipulated and actual cumulative performances of the beating points, as is presented in Table 2.

From Table 2, it can be noted that after the Mono cylinder and the ERM opener, the difference is high; that is, in the case of stipulated 55% of CE, the achieved CE is

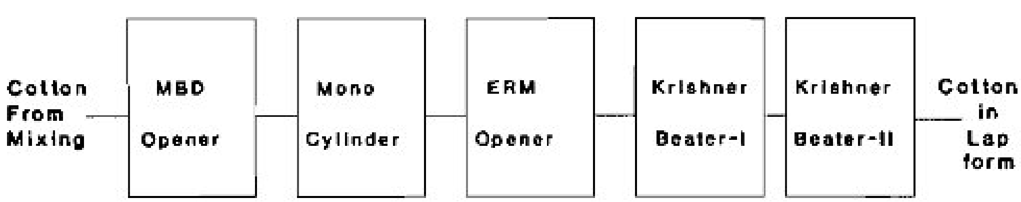

Figure 1. Schematic diagram of blow-room operation.

Table 1. Cleaning Efficiency of the Blow Room

BEATING POINTS	TRASH WEIGHT (g) 1	2	3	4	Avg	CLEANING EFFICIENCY	STANDARD EFFICIENCY
Mixing	6.13	6.16	6.49	6.00	6.195	—	—
MBD opener	5.05	5.60	5.26	5.00	5.230	15.57	20–25
Mono cylinder	4.67	4.26	3.88	4.13	4.235	19.02	25–30
ERM opener	3.75	3.68	3.85	3.70	3.745	11.57	25–30
Krishner beater I	3.53	3.16	3.42	3.55	3.415	8.81	8–10
Krishner beater II	2.57	3.92	3.21	3.76	3.365	1.46	8–10
Overall						45.68	65–70

Table 2. Comparison of Cumulative Cleaning Efficiency

BEATING POINT	CUMULATIVE CLEANING EFFICIENCY: STIPULATED (AT MIN.)	ACTUAL	DIFFERENCE
MBD opener	20	15.57	4.43
Mono cylinder	40	31.64	8.36
ERM opener	55	39.55	15.45
K. beater I	58.6	44.87	13.73
K. beater II	61.9	45.68	16.23
Overall	65	45.68	19.32

only 39.55%. It was thus clear that the poor CE at the Mono cylinder and ERM opener reflected the poor performance in the blow room. Hence, initially, further study was restricted to improvement of the performances of the Mono cylinder and the ERM opener.

The setting and process parameters at these two beating points were as per mills standard, and it was followed regularly. But the machine manufacturer recommends a wide range of settings and process parameters based on requirement. This was discussed and, finally, it was decided to do an experiment to study the effect of the process parameters on the CE.

Experimentation

Factor and Level Selection

The factors selected for experimentation and reason for selection are as follows:

(a) The shorter running time of the ERM feed rollers results in fewer beats per inch, and so affects the CE.

(b) The setting of the Mono cylinder opener (MCO) (both angle and distance) and the ERM opener decides the feed of cotton and removal of trash, and thus affects the CE.

(c) The setting between the ERM feed roller and the beater may affect the CE.

During the discussion with technical personnel it was decided to screen the factors for determining whether they have any effect on the CE. Also, it was felt that the effects of the factor were linear. For this reason, two levels were selected for each factor. The value of each factor level, for experimentation, was selected based on discussions and reference to a machine manufacturing catalog. This is presented in Table 3. The current production setting is taken as level I because this was considered a reference point.

Designing the Experiment

As explained earlier, the CE depends on three beating points and factors were selected at all beating points. It is likely that the factors may interact with each other. For this

Table 3. Factors and Levels for Experimentation

FACTORS		LEVEL I[a]	LEVEL II
ERM running time	(A)	40%	72%
MCO setting angle	(B)	6 mm	10 mm
MCO setting distance	(C)	5 mm	4 mm
ERM feed roller setting	(D)	4.5 mm	3 mm
ERM opener setting	(E)	4 mm	3 mm

[a]Level I refers to existing setting.

reason, it was decided to study all two-factor interaction effects along with all the main effects. Higher-order interactions were not considered because they are difficult to interpret in a practical situation. Again, in order to estimate higher-order interactions, it is required to increase the number of trials, which is not feasible due to raw material and time constraints.

In order to estimate all main effects and their interactions, we required a minimum of 15 degrees of freedom (d.f.):

For 5 main effects	5 d.f.
For 10 ($^5C_2$), two-factor interaction effect	10 d.f.
Total	15 d.f.

The nearest orthogonal array which can accommodate this experiment is $L_{16}(2^{15})$ because it has 15 d.f. So, $L_{16}(2^{15})$ was chosen for the experiment with a minimum of 16 trials; the experimental layout is given in Appendix I. As all the 15 d.f. are necessary to estimate the main effect and the interaction effect; it is not possible to estimate the experimental uncertainty or error. In order to estimate the error, the experiment has to be replicated; it was decided to replicate the experiment four times. By replicating four times, we have $(4 \times 16) - 1 = 63$ d.f., of which 15 d.f. are for the model itself. So without changing the model, we have $63 - 15 = 48$ d.f. for estimating error.

Conducting the Experiment

During the experiment, all other factors (other than in Table 3) were kept at their usual specified level. Cotton feeding at first beating points was monitored strictly. At each trial, samples were collected as described earlier and the cleaning efficiencies after the ERM opener and overall were measured. All the trials were replicated four times, as decided. The data are given in Appendix II.

During the experiment, the CE was observed to be higher than the usually observed performance. This was possibly due to the strict control exercised during experimentation.

Analysis

Data were analyzed using ANOVA techniques for the CE after the ERM beating point. The results of the analysis are given in Table 4 and the average response of the significant factors are given in Tables 5 and 6.

Data were analyzed through by ANOVA for the overall CE. The results of the analysis are given in Table 7, and the average response of the significant factor is given in Tables 8 and 9.

Inference and Deciding Remedial Measures

Factors significant for the CE after the ERM opener are A, B, BC, and AE and for the overall CE they are A, C, D, BE, and DE. Among the significant factors, A is most critical as the factor significant at the 1% level in both cases. The CE is high when the factor (A) is in the second level for both cases and that is why level 2 of factor A was recommended. For other factors, levels were selected by comparing the average response tables (Tables 5, 6, 8, and 9). The recommended settings are presented in Table 10.

The expected overall CE at this setting (A2 B1 C1 D1 E1) is 57.51%, which is less than the target value of 65%. So it is necessary to study the process more elaborately. Although it was usually done by elaborate experimental design (surface response, etc.), it was decided to study the factors individually, with the information gathered from the screening experimentation.

The machine running time of the MB opener was kept at 35% and the factor was not selected for experimentation. From the experiment, it is clear that the machine running time of the ERM opener has a significant effect on the CE. So, it was planned to study the effect of the MB opener running time.

The machine running time for the MB opener was changed from 35% to 80% and the cleaning efficiency was studied. The result is presented in Table 11. This table shows that there is an improvement in the cleaning efficiency, but it is not at the desired level.

At the time of examining the beaterwise cleaning efficiency, it was observed that the CE at Krishner Beaters are at only 8.81% and 1.46% which is less than the standard norm of 8–10%.

Table 4. Analysis of Variance for CE After ERM Beating Point

SOURCE OF VARIATION	d.f.	SUM OF SQUARES	MEAN SUM OF SQUARES	*F*-RATIO
A	1	3681.60	3681.60	5156[a]
B	1	3.87	3.87	4.96[b]
C	1	0.73	0.73	<1
D	1	0.40	0.40	<1
E	1	0.17	0.17	<1
AB	1	0.05	0.05	<1
AC	1	0.01	0.01	<1
AD	1	0.38	0.38	<1
AE	1	3.23	3.23	4.10[b]
BC	1	4.23	4.23	6.45[b]
BD	1	0.17	0.17	<1
BE	1	0.37	0.37	<1
CD	1	1.88	1.88	2.97
CE	1	0.34	0.34	<1
DE	1	0.63	0.63	<1
Error	48	37.99	0.79	
Pooled error	58	41.29	0.71	
Total	63	3736.04		

[a]Significant at 1% level.
[b]Significant at 5% level.

Table 5. Average Response of CE After ERM Opener

FACTOR	AVERAGE CLEANING EFFICIENCY LEVEL 1	LEVEL 2
A	39.10	54.27
B	46.44	46.93

The factors which affect the CE at Krishner Beaters are beater setting, beater speed, and fan speed. The speed of the beater and the setting are as per mill standard. But the fan speed is within a wide range. Thus, it was decided to observe the effect of fan speed on cleaning efficiency.

Changing the fan speed from 1250 rpm to 1150 rpm, the cleaning efficiency was studied as per the earlier method. The results are summarized and presented in Table 12. The results confirm that CE improves with reduction in fan speed.

Implementation of Remedies

The above findings were implemented in all regular lines. The CE was measured after implementation and the results were as presented in Table 13. All lines gave satisfactory results, which are being maintained.

Table 6. Average Response of CE (Interaction Effect)

FACTOR	FACTOR C LEVEL 1	FACTOR C LEVEL 2	FACTOR E LEVEL 1	FACTOR E LEVEL 2
B1	46.07	46.80		
B2	47.08	46.78		
A1			38.92	39.27
A2			54.54	53.99

Table 7. Analysis of Variance for Overall CE

SOURCE OF VARIATION	d.f.	SUM OF SQUARES	MEAN SUM OF SQUARES	F-RATIO
A	1	596.28	596.28	2775[a]
B	1	0.02	0.02	<1
C	1	1.57	1.57	7.29[b]
D	1	1.16	1.16	5.41[b]
E	1	1	1	<1
AB	1	0.22	0.22	<1
AC	1	0.22	0.22	<1
AD	1	0.24	0.24	1.11
AE	1	0.41	0.41	1.94
BC	1	0.01	0.01	<1
BD	1	0.63	0.63	2.93
BE	1	1.71	1.71	7.97[b]
CD	1	0.11	0.11	<1
CE	1	0.15	0.15	<1
DE	1	1.00	1.00	4.64[b]
Error	48	11.09	0.23	
Pooled error	56	12.25	0.22	
Total	63	614.84		

[a]Significant at 1% level.
[b]Significant at 5% level.

Table 8. Average Response of Overall CE

FACTOR	AVERAGE CLEANING EFFICIENCY	
	LEVEL 1	LEVEL 2
A	50.96	57.06
C	54.17	53.85
D	54.14	53.87

Table 9. Average Response of CE (Interaction Effect)

FACTOR	FACTOR B		FACTOR D	
	LEVEL 1	LEVEL 2	LEVEL 1	LEVEL 2
E1	54.21	53.85	54.29	53.77
E2	53.84	54.14	54.00	53.98

Table 10. Recommended Setting

FACTOR	LEVEL	ACTUAL VALUE
A	2	72%
B	1	6 mm
C	1	5 mm
D	1	4.5 mm
E	1	4 mm

Table 11. CE at Different Machine Running Times

QUALITY CHARACTERISTICS	MB OPENER RUNNING TIME	
	35%	80%
Trash in cotton	6.25%	6.08%
Trash in lap	2.75%	2.43%
Cleaning efficiency	56.00	60.03

Table 12. CE at Different Fan Speeds

QUALITY CHARACTERISTICS	FAN SPEED	
	1250 rpm	1150 rpm
Trash in cotton	6.42%	6.32%
Trash in lap	2.50%	2.30%
Cleaning efficiency	61.06	63.61

Table 13. Comparison of CE Before and After Study

LINE	BEFORE STUDY	AFTER STUDY
LR-1	45.6	61.0
NSE-1	51.0	63.2
NSE-2	51.0	63.8
TRUMAC	50.0	68.7

Appendix I

Experimental Layout

TRIAL NO.	ERM FEEDFEED RATE (%)	MCO SETTING ANGLE (mm)	MCO SETTING DISTANCE (mm)	ERM FEED SETTING (mm)	ERM OPENER SETTING (mm)
1	40.0	6	5	4.5	4
2	40.0	6	5	3	3
3	40.0	6	4	4.5	3
4	40.0	6	4	3	4
5	40.0	10	5	4.5	3
6	40.0	10	5	3	4
7	40.0	10	4	4.5	4
8	40.0	10	4	3	3
9	72.0	6	5	4.5	3
10	72.0	6	5	3	4
11	72.0	6	4	4.5	4
12	72.0	6	4	3	3
13	72.0	10	5	4.5	4
14	72.0	10	5	3	3
15	72.0	10	4	4.5	3
16	72.0	10	4	3	4

Appendix II

Cleaning Efficiency After ERM Opener

TRIAL	CLEANING EFFICIENCY				
NO.	1	2	3	4	AVERAGE
1	35.99	38.33	38.72	39.89	38.23
2	38.33	39.11	39.89	38.72	39.01
3	39.89	39.42	39.11	38.72	39.29
4	38.72	38.72	39.11	39.42	38.99
5	39.89	39.89	39.11	39.42	39.58
6	39.42	39.42	39.11	38.72	39.17
7	40.28	39.11	39.11	38.72	39.30
8	39.11	39.11	39.42	39.21	39.21
9	55.06	55.06	50.30	52.30	53.18
10	55.06	54.19	53.76	52.46	53.87
11	55.92	55.49	55.49	53.76	55.17
12	54.19	53.76	53.76	53.33	53.76
13	55.92	55.06	54.62	54.19	54.95
14	55.06	54.62	54.62	54.19	54.62
15	54.62	54.62	54.19	54.19	54.41
16	54.62	54.19	54.19	53.76	54.19

Appendix III

Overall Cleaning Efficiency

TRIAL	CLEANING EFFICIENCY				
NO.	1	2	3	4	AVERAGE
1	51.20	51.20	52.38	51.99	51.69
2	50.81	50.42	51.20	50.81	50.81
3	51.20	50.81	50.81	50.42	50.81
4	51.20	50.81	50.81	50.42	50.81
5	51.20	50.81	50.81	50.42	50.81
6	51.20	51.20	50.81	50.42	50.91
7	51.20	50.81	50.81	50.42	50.81
8	51.20	51.20	50.81	50.81	51.01
9	56.35	58.08	57.64	56.78	57.21
10	57.22	57.22	56.78	56.78	57.00
11	57.64	57.64	57.22	56.78	57.32
12	57.22	56.35	56.68	55.92	56.54
13	58.08	57.64	57.22	56.35	57.32
14	57.64	57.64	57.22	57.78	57.57
15	57.22	57.78	57.78	55.92	57.18
16	56.78	56.35	56.35	55.92	56.35

Conclusion and Recommendation

From the above study, the following are concluded:

(i) The CE of the blow room is improved from 49% to 61% by changing the process parameters. The various process parameters as recommended in Table 10 and subsequent studies should be maintained regularly.
(ii) Better process control and strict monitoring of the process improves the CE.
(iii) It is recommended to identify the beating zones for improvement of blow-room performance based on the above-mentioned method, as shown in Table 2.

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