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Effect of Process Variables on Yarn Quality in High-Speed Combers

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ABSTRACT

In yarn manufacturing process, the comber plays a major role in improving the quality of raw materials by removing short fibres, impurities, neps and hooks . It improves the important yarn characteristics like evenness, strength and appearance. The quality of combed yarn depends on many factors such as raw material, lap preparation methods, factors associated with machine, machine setting and ambient conditions [1]. In combing machine, higher speed is the basic criteria for high productivity. Therefore, in order to achieve high speed and stable operation of modern combers, it is required to optimize the drive mechanism especially in nipper drive, detaching roller drive and unicomb drive. The effect of various process variables on yarn quality was studied.

KEYWORDS: *comber, Feed per nip, Lap, hi speed combers*

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INTRODUCTION:

In yarn manufacturing process, the comber plays a major role in improving the quality of raw materials by removing short fibres, impurities, neps and hooks. It improves the important yarn characteristics like evenness, strength and appearance. The quality of combed yarn depends on many factors such as raw material, lap preparation methods, factors associated with machine, machine setting and ambient conditions [1]. In combing machine, higher speed is the basic criteria for high productivity. Therefore, in order to achieve high speed and stable operation of modern combers, it is required to optimize the drive mechanism especially in nipper drive, detaching roller drive and unicomb drive. The speed of modern comber is 200% higher than old combers and reached up to 600 nips per minute. While increasing machine speed, there should not be any compromise on quality of output material as it is increasing day by day. High speed combers can meet the spinning process of lap weight to 80 g/m which is 33% higher than lap weight processed at old combers. This paper reveals the effect of process variables on yarn quality in high speed combers.

Materials:

100% MCU-5 cotton variety was selected for this trial. Fibre properties are measured in USTER HVI 1000 tester are listed in: 2.5% Span length -29mm; SFI-6.5; Uniformity ratio – 0.46; Strength -23 grams/tex; Fineness-4.2 and blend ratio – 100%.

Methodology

Productivity and quality are critical terms in spinning industry which are influenced by many factors such as material, machine setting and machine technology. In this paper, machine parameters such as machine speed, feed per nip, noil% and top comb depth were considered to study the effect of above such parameters on yarn quality. Further practical trials are conducted with various mixing to assess the performance. It was found that the above changes have significant influence on production and quality of output material. LMW LK64 high speed comber was chosen for this trial. The process parameters for various trials are listed in Table 1.

Table 1: Process parameters of various trial

Sample No	Comber speed	Feed/Nip	Type of feed	Noil%	Top comb depth
1	350	5.2	Forward	15	+0.5
2	400	5.2	Forward	15	+0.5
3	450	5.2	Forward	15	+0.5
4	450	5.2	Forward	20	+1
5	450	5.2	Forward	20	+0.5
6	450	5.9	Forward	20	+0.5
7	450	5.9	Forward	15	+0.5

Preparation of samples:

The prepared cotton mixing was processed through blowroom, carding, drawframe and unilap machines and comber laps were prepared. Ideal spinning preparatory machinery sequence with ideal process parameters were followed during sample preparation. The Prepared comber laps were processed through high speed modern combers with different process parameters. The combed slivers were processed through finisher drawframe, speedframe and ring frame with/without compact system to produce yarn samples. The details of process parameters and production details of different trials conducted at different category of combers are shown in Table 2.

Table 2: Details of various process

Card Sliver Hank	C60- 0.11 Ne
Precomber Drawframe	SB2
No. Of Doubling	5
Total Draft	5.23
Lap Former - No Of Ends	E32-22
Total Draft	1.5
Lap Weight	74 g/m
Drawing Speed (MPM)	350
Speed Frame- Hank	68i -1.0 Ne
TM	1.22
Ring Frame - Count	40 Ne

TESTS

Fibres

The fibres from comber lap, sliver and noil were tested for nep count, length, 5% span length, SFC and maturity ratio in Uster AFIS Pro instrument. The noil% was measured by the following method. The machine was run at slow speed to clean the circular comb. The comber noil collection box, the suction pipe and the top comb were cleaned. The machine was allowed to run at operating speed for a period of 15 seconds. The comber noil and sliver were collected.

$$Noil\,\% = \frac{Weight\ of\ noil}{Weight\ of\ noil + weight\ of\ sliver}\ x\,100$$

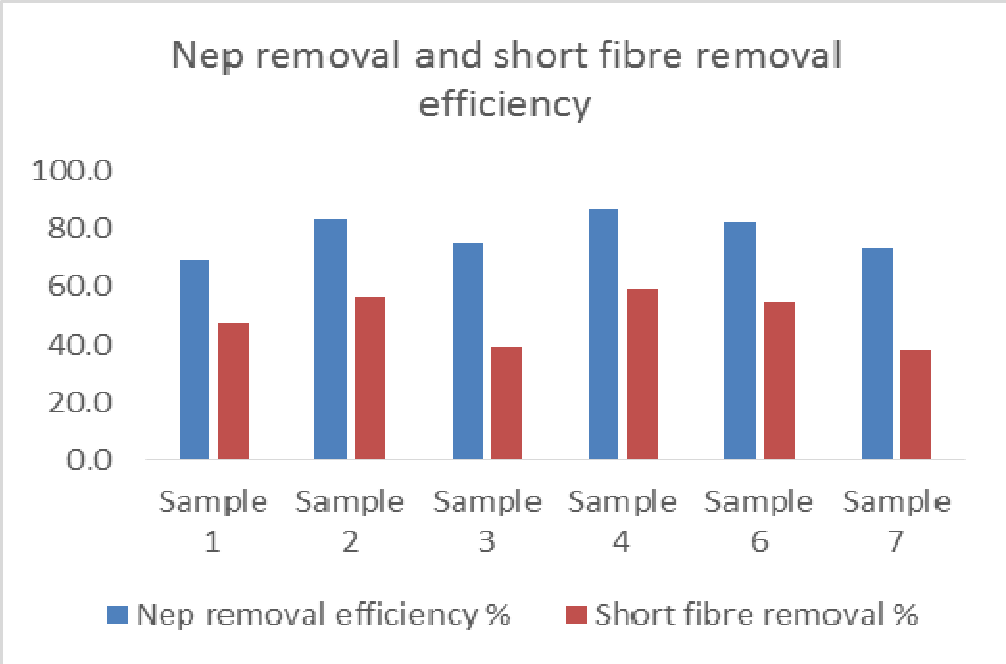
Yarns

The yarn evenness and imperfections were evaluated on Uster Evenness Tester 4 with 400 m/min speed and 1 min testing time at -50%, +50% and +200% sensitivity levels for thin places, thick places and neps respectively. Also -40%, +35% and +140% sensitivity levels were used for higher sensitivity faults. Further yarn samples were also tested for classimat faults in Uster classimat tester where total classimat faults, 16 class, 10 class, 7 class, long thick and long thin faults were measured.

RESULTS AND DISCUSSION

Fibre and sliver Properties

Table 3 shows that the short fibre removal efficiency and nep removal efficiency of all the samples.



The nep removal efficiency and short fibre removal efficiency of sliver sample 2 is higher than the sample 1 and 3. While increasing the machine speed from 350 to 400 npm, the short fibre removal and nep removal efficiency initially increases to certain extent and then decreases while increasing machine speed to 450 npm. But the results at 450 npm is still higher than at 350 npm. Hence, considering the production, the optimized machine speed was identified as 450 npm. NRE and SRE of sample 4 is better than all the samples due to extraction of higher noil% and increased top comb depth. In sample 7, While increasing feed per nip to 5.9mm, the NRE and SRE were found decreased when compared to sample 4. This may be due to higher amount of feeding. Subsequently, increasing noil% increases the NRE and SRE in sample 6 when compared to sample 7.

Table 3: Nep and Shor fibre removal efficiency of various samples

TEST PARTICULARS	SAMPLE 1			SAMPLE 2			SAMPLE 3	
NEP RESULTS	LAP	CAN SLIVER	NOIL	LAP	CAN SLIVER	NOIL	LAP	CAN SLIVER
TOTAL NEP CNT(CNT/G)	112	35	543	123	20	438	73	18
TOTAL NEP MEAN SIZE(µm)	637	627	673	656	628	680	714	626
FIBER NEP CNT(CNT/G)	103	33	485	107	19	381	54	15
FIBER NEP MEAN SIZE(µm)	621	612	641	610	620	638	624	590
SCNEP COUNT(CNT/G)	10	2	58	16	1	58	19	2
SCNEP MEAN SIZE(µm)	802	858	932	929	875	952	953	875
LENGTH RESULTS								
L(w) (MM)	25.9	26.4	11.9	25.9	26.9	12.6	27.2	27.2
L(w) CV%	38.7	35.8	57.1	38	34.8	54.7	34.1	33.5
SFC(w) (%<12.7 mm)	9.3	5.2	60	8.7	4	55	6.1	4.1
UQL(w) [MM]	32.4	32.3	15	32.2	32.7	15.9	33.2	33
L(n) [MM]	20.4	22.4	8.7	20.6	23.2	9.3	22.4	23.5
L(n) [CV%]	52.3	42.4	61.3	50.6	40.2	59.7	45.9	39.9
SFC(n) [%<12.7 mm]	26.1	13.8	79.5	24.4	10.7	75.2	18.8	11.4
5% L(n) [MM]	37.6	38.1	18.9	37.3	38.7	19.7	38.1	38.3
FINENESS [mtex]	163	168	147	163	171	148	165	170
MATURITY RATIO	0.91	0.95	0.72	0.91	0.96	0.73	0.94	0.97
IFC [%]	5.5	4.1	14.5	5.7	3.8	13.5	4.7	3.7
Nep removal efficiency %	68.8			83.7			75.3	
Short fibre removal %	47.1			56.1			39.4	

TEST PARTICULARS	SAMPLE 4			SAMPLE 6			SAMPLE 7		
NEP RESULTS	LAP	CAN SLIVER	Noil	LAP	CAN SLIVER	Noil	LAP	CAN SLIVER	Noil
TOTAL NEP CNT(CNT/G)	87	11	371	79	14	370	107	28	615
TOTAL NEP MEAN SIZE(μm)	657	574	674	677	582	674	697	640	692
FIBER NEP CNT(CNT/G)	72	11	305	64	14	316	92	25	535
FIBER NEP MEAN SIZE(μm)	621	566	635	627	582	631	635	618	653
SCNEP COUNT(CNT/G)	15	1	66	15	0	54	15	3	80
SCNEP MEAN SIZE(μm)	880	650	859	866	0	925	1037	811	948
LENGTH RESULTS									
L(w) (MM)	26.5	27.7	13.8	26.8	27.6	13.4	26.8	27	12.1
L(w) CV%	35.2	32	59	34.3	32.1	56.8	35.5	33.8	60.4
SFC(w) (%<12.7 mm)	7.3	3.1	51.5	6.4	3.1	51.5	6.9	4.7	60.2
UQL(w) [MM]	32.7	33.2	17.9	32.9	32.9	17.2	32.8	32.8	15.2
L(n) [MM]	21.5	24.3	9.7	22.1	24.2	9.7	21.8	23.1	8.6
L(n) [CV%]	47.9	37.7	64.8	46.1	37.4	62.5	47.8	41	63.8
SFC(n) [%<12.7 mm]	21.6	8.8	74	19.4	8.8	73.4	20.9	12.9	80.1
5% L(n) [MM]	37.4	38.8	22.5	37.5	38.4	21.8	37.9	38.1	19.4
FINENESS [mtex]	163	170	145	163	170	147	163	168	144
MATURITY RATIO	0.92	0.97	0.75	0.93	0.97	0.76	0.93	0.96	0.73
IFC [%]	5.4	3.8	12.8	4.7	4.1	11.5	4.9	4.1	13.7
Nep removal efficiency %	87.4			82.3			73.8		
Short fibre removal %	59.3			54.6			38.3		

Table 4: Test results of yarn samples

TEST PARAMETERS	SAMPLE 1				SAMPLE 2				SAMPLE 3	
	LR6/S		K441		LR6/S		K441		LR6/S	
	COP	CONE	COP	CONE	COP	CONE	COP	CONE	COP	CONE
COUNT	40.6	41.0	40.4	40.1	42.0	40.5	39.9	40.2	39.1	39.9
STRENGTH	71.3	67.2	84.2	84.4	63.7	67.7	81.8	86.3	76.1	72.1
CSP	2897.0	2752.0	3396.0	3380.0	2674.0	2740.0	3263.0	3465.0	2978.0	2880.0
U%	9.9	10.0	9.8	10.0	10.1	10.0	9.4	9.7	9.6	9.9
CVm	12.5	12.6	12.4	12.6	12.8	12.6	11.9	12.2	12.1	12.5
THIN -40%	1059.0	1156.0	937.0	1119.0	1183.0	1075.0	781.9	927.9	35.4	49.6
THIN -50%	63.4	74.2	48.0	71.7	73.9	63.3	34.5	39.6	0.3	0.8
THICK +35%	1.0	0.8	1.6	3.8	1.1	0.8	0.1	0.4	251.9	310.8
THICK +50%	248.1	280.0	268.1	332.9	315.5	288.3	204.1	239.6	28.8	23.8
NEPS +140%	22.0	28.8	33.1	33.3	36.6	30.8	21.3	22.9	342.6	581.3
NEPS +200%	319.3	566.7	281.3	415.0	428.5	476.3	195.3	267.1	91.3	101.3
NEPS +280%	68.0	90.8	70.4	90.4	109.6	83.8	46.0	65.8	105.0	85.0
H	4.5	5.9	3.3	4.3	4.6	6.0	3.3	3.9	4.5	6.0
SH	1.0	1.4	0.7	1.0	1.0	1.4	0.7	0.9	1.0	1.4
Total IPI	630.8	920.9	597.4	819.6	817.9	827.9	433.9	546.3	120.4	125.9
Higher sensitivity	91.0	120.4	105.1	127.5	147.3	115.4	67.4	89.1	699.5	977.1

TEST PARAMETERS	SAMPLE 4		SAMPLE 5		SAMPLE 6		SAMPLE 7	
	K441		LR6/S		K441		K441	
	COP	CONE	COP	CONE	COP	CONE	COP	CONE
COUNT	40.3	40.7	39.7	39.7	40.3	40.4	40.3	40.4
STRENGTH	82.4	84.9	75.4	73.6	82.2	82.9	83.3	83.1
CSP	3322.0	3451.0	2990.0	2919.0	3315.0	3354.0	3357.0	3356.0
U%	9.4	9.5	9.6	10.1	9.4	9.6	9.8	10.0
CVm	11.8	11.9	12.1	12.7	11.8	12.1	12.4	12.6
THIN -40%	30.3	22.5	39.9	69.2	28.8	33.3	45.0	56.7
THIN -50%	0.1	0.8	0.0	0.0	0.3	0.0	0.3	1.7
THICK +35%	189.0	195.0	218.1	303.3	208.1	208.8	333.0	345.8
THICK +50%	18.3	17.5	20.9	26.3	22.4	23.8	50.2	39.2
NEPS +140%	174.8	230.8	278.5	536.3	217.8	283.2	411.9	539.2
NEPS +200%	40.1	50.8	65.0	95.8	57.2	70.4	119.3	125.4
NEPS +280%	11.1	14.2	20.7	17.9	14.3	15.4	38.1	35.4
H	3.3	4.0	4.5	5.9	3.3	4.1	3.5	4.3
SH	0.7	1.0	1.0	1.4	0.7	1.0	0.8	1.0
Total IPI	58.5	69.1	85.9	122.1	79.9	94.2	169.8	166.3
Higher sensitivity	374.9	440.0	517.3	857.5	440.2	507.4	783.0	920.4

Yarn Properties

There is no significant difference noticed in unevenness% of all the yarn samples and lies in the range of 9.5 to 10%. Total IPI in cop level of sample 2 is 30% higher in ring yarn and 27% lower in compact yarn when compared to sample 1. This is due to the increase of machine speed from 350 to 400 npm. Even though the sample 6 is having 5.9mm feed, Total IPI in cop of sample 6 is 6% lower when compared to sample 5. While reducing noil% of sample 6 to 15%, the IPI in cop is raised to 100%. This was due to less short fibre extraction.

In case of higher sensitivity faults, there is a raising trend noticed while increasing the speed and feed per nip. The strength of compact yarn is higher than the strength of ring yarn. This is due to better consolidation of fibres in the compacting zone. But there is no significant different noticed in the samples due to change in the process variables of comber.

In classimat fault, there is no significant difference between sample 1 and sample 2. i.e. there is no much difference between yarn samples taken at 350 npm and 400 npm.

CONCLUSION

- Nep removal efficiency and short fibre removal efficiency increases while increasing machine speed.
- Yarn IPI level increases with machine speed, feed per nip and lower noil%.
- There is no significant difference noticed in yarn strength in all the trials.
- The higher sensitivity and classimat faults are having significant difference while increasing machine speed, feed per nip and lower noil%.

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