Indian Journal of Fibre & Textile Research
Vol. 33, September 2008, pp. 264-268

Design and development of an instrument to evaluate staple fibre processing propensity

Arindam Basu[a]
The South India Textile Research Association, Coimbatore 641 014, India

An instrument has been developed to measure the combined effect of fibre coherence and resiliency, commonly known as processing propensity. The results show good correlation between fibre processing propensity and yarn properties. The yarns produced with high propensity value cotton show higher imperfections when same process parameters are used.

Keywords: Cohesive force, Drafting tenacity, Processing propensity, Resiliency, Torque, Yarn imperfections

1 Introduction

In staple fibre spinning, such as in case of cotton, polyester and viscose, the fibre cost contributes to around 50 – 70% of total yarn cost. Also, the yarn properties and process efficiency are heavily dependent on fibre properties. The fibre properties generally considered for the selection of raw material and the process parameters are fibre length, strength, elongation and fineness for all fibres; cotton maturity is also considered besides the above-mentioned properties. It has been found that these properties cannot explain some of the fibre behaviour during mechanical processing.

In the fibre-to-yarn conversion systems, fibres are subjected to various modes of deformations including tension, bending and compression. In addition, fibres are being pulled and rubbed against each other or against other surfaces before they are finally consolidated into a yarn. The fibres are able to accommodate these deformation modes based on their combined levels of coherence and resiliency. The major problem encountered with the effects of these two basic characteristics is that the resiliency and cohesion act simultaneously and very low or very high levels of their values are not practically desirable during processing. High cohesion value results in a slow recovery of fibres upon removal of processing stresses. In extreme cases such as scoured cottons used for nonwoven, fibre cohesion increases substantially due to the loss of natural wax; consequently fibre bulk resiliency deteriorates.[1,2] The importance of inter-fibre coherence and fibre bulk resiliency in determining fibre processing performance has been discussed by few researchers.[3-6]

Though there are wide spread recognition of the roles of fibre coherence and resiliency in textile processes, reliable measures of their combined effects do not exist. El Mogahzy *et al.*[7,8] called the combined effect as 'processing propensity' and tried to examine these values for cotton and some man-made fibres. The study was only at the experimental level. Considering the importance of these parameters, in this study an instrument has been developed which can be used to measure the processing propensity of staple fibres.

2 Materials and Methods

Seven varieties of cottons were tested using the instrument. One metre length of sliver of hank around 0.14 was passed through the tester and results were observed. The same cottons were tested for basic fibre properties and cohesive force. For measuring the drafting tenacity or cohesive force Instron tensile tester was used and ASTM D2612-99 method was followed. The results are shown in Table 1.

2.1 Principle of Operation

The instrument developed follows the principle of opening roller of rotor spinning unit. The feed roller and opening roller unit of rotor spinning machine have been used with some modifications. The purpose of this modification is to simulate the carding action. A sand paper of known fineness has been mounted inside the wall of bottom casing. The sand paper is used instead of typical carding segment because of limited fixed space between the casing and the opening roller. The schematic diagram (Fig. 1)

[a]E-mail: sitraindia@dataone.in

Table 1—Fibre processing propensity and other properties of different cottons

Property	MCU 5	DCH 32	US PIMA	BRAHMA	GIZA 88	S6	BUNNY
Sliver hank, Ne	0.14	0.135	0.141	0.137	0.145	0.137	0.14
2.5% span length, mm	30.1	31.3	34.8	30.8	34.8	28.5	28.7
Uniformity ratio	45.8	43	47	46.3	47.8	45	42.5
Strength, gf/tex	23.2	24	30.6	24	32.6	23.4	23
Elongation, %	7	7.3	7	6.9	7.3	6.3	6.4
Fibre fineness, µg/inch	3.2	2.7	3.5	3.5	3.4	3.7	3.2
Sample length, m	1	1	1	1	1	1	1
Feed roller speed, rpm	28	28	28	28	28	28	28
Opening roller speed, rpm	1794	1794	1794	1794	1794	1794	1794
Propensity[a], mg.m	3400	2800	4600	2800	4200	2700	3300
Breaking force, gf	157.1	142.2	238.9	143.5	244.8	164.2	160.6
Elongation, %	12.97	14.82	12.89	12.54	11.09	12.52	15.2
Drafting tenacity, mgf/tex	36.42	34.73	57.37	34.59	54.7	36.75	33.9

[a] Fibre cohesion test (Instron), Gauge length : 100 mm, Speed : 254 mm/min, and Load : 5 kg.

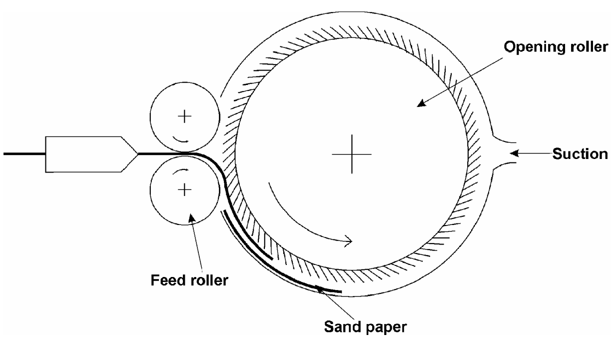

Fig.1—Schematic diagram of processing propensity tester

explains the principle. When the fibres are passed through the opening roller, due to carding action the fibres cause some torque to the opening roller. Keeping all other parameters such as feed roller speed, opening roller speed and suction force constant, the torque is measured using an electronic torque sensor. The fibre, which causes more difficulty during carding, is expected to create more torque due to higher bulk resiliency and cohesion.

2.2 Description of Instrument

Based on the principle mentioned above an instrument has been developed (Fig. 2) for measuring the combined effect of fibre cohesion and resiliency. The opening roller is driven through an independent motor M_1. Between the opening roller and motor, a torque sensor (TS) has been fixed. The feed rollers are driven by another motor (M_2) independently. These two motors are controlled by electronic control panels C_1 and C_2. The advantage of these two independent drives is that the opening roller and feed roller speed

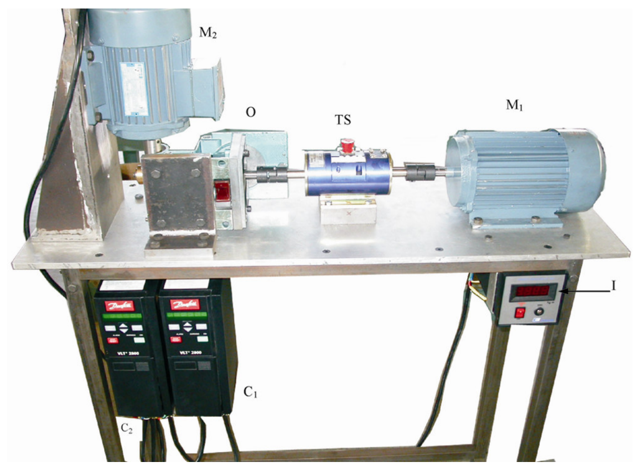

Fig. 2—Fully assembled unit [M_1–Opening roller drive motor, M_2–Feed roller drive motor, TS–Torque sensor, C_1 & C_2–Electronic control panels, I–Indicator, and O–Opening roller]

can be varied independently. As the cotton in sliver form is fed through feed roller, the carding action between the sand paper and the pins of opening roller takes place causing a resistance to the opening roller drive. This resistance is dependent on fibre's processing propensity. The torque experienced by the opening roller shaft measures this resistance. The torque sensed by the sensor is reported in the indicator I.

For easy passage of the fibres one side of the opening roller (Fig. 3) is opened and suction force is applied to suck the fibres. A small vacuum cleaner is fitted to pull the fibres after going through the carding process to avoid opening roller clogging by the fibres. The opening roller speed can be varied from 560 rpm to 3400 rpm and the feed roller speed from 5.54 rpm to 33.25 rpm, i.e. from 43.5 cm/min to 261 cm/min. The feed roller diameter and opening roller diameter are 25mm and 62 mm respectively. The torque is expressed in milligram metre (mg.m). For experimental purpose, trials were undertaken at various feed roller speeds and opening roller speeds. For the cottons used in the experiments, the results are found to be stable and reproducible at a feed roller speed of 28 rpm and opening roller speed of 1794 rpm. Hence, for the preliminary trials, these speeds are maintained.

3 Results and Discussion

The processing propensity varies from 2700 mg.m to 4600 mg.m for the cottons used in this study. It can be seen from Table 1 that as per the expectation the fibre cohesive force is highly correlated with fibre processing propensity (r = 0.92). Further analysis shows that the fibre length, strength and length uniformity are well related to fibre propensity with the correlation coefficients (r) 0.82, 0.86 and 0.601 respectively. The imported fibres, used in this trial, show higher length, strength and cohesive force values. Longer and stronger fibre is expected to have higher resiliency. It has been mentioned earlier that the cohesive force and resiliency together form the fibre processing propensity. The higher processing propensity values of Giza and PIMA may be explained by these factors. Earlier study[9] has shown that the fibres of similar length, strength, and fineness values perform differently on the machines due to difference in cohesive force. Also, the fibres with higher cohesive force produce inferior quality yarns if processing parameters, such as break draft and roller gauge, are not changed accordingly.

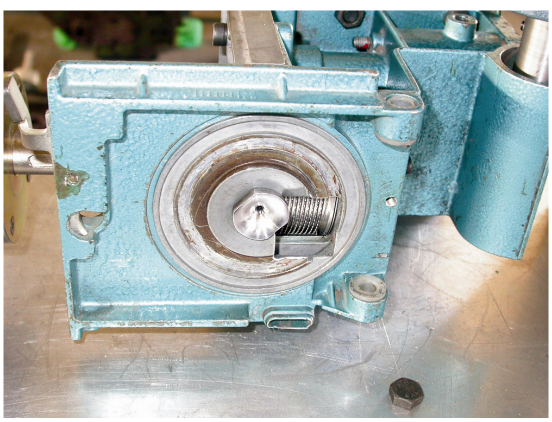

Fig.3 — Magnified view of opening roller (O)

Table 2 reports the properties of yarns produced by using US Pima and Giza 88 cottons with varying process parameters. The analysis of properties of US Pima and Giza 88 cottons show that their 2.5% span lengths are same, uniformity ratios are nearly equal, tensile properties are nearer (strength difference is 6%) and micronaire is nearer. The only noticeable difference is the propensity value. Hence, the yarns were produced using these two cottons keeping all process parameters the same. The ring frame spindle speeds were varied from 18000rpm to 22000rpm and comber noil level was varied form 12% to 18%. Yarns of fineness values 60s Ne, 80s Ne and 100s Ne were spun. It can be seen from Table 2 that in all the cases the yarns produced from US Pima show higher number of imperfections (Fig. 4). Higher fibre propensity values of US Pima cotton might have caused higher resistance during carding and drafting operations causing more un-drafted bunches in the yarns and more number of neps.

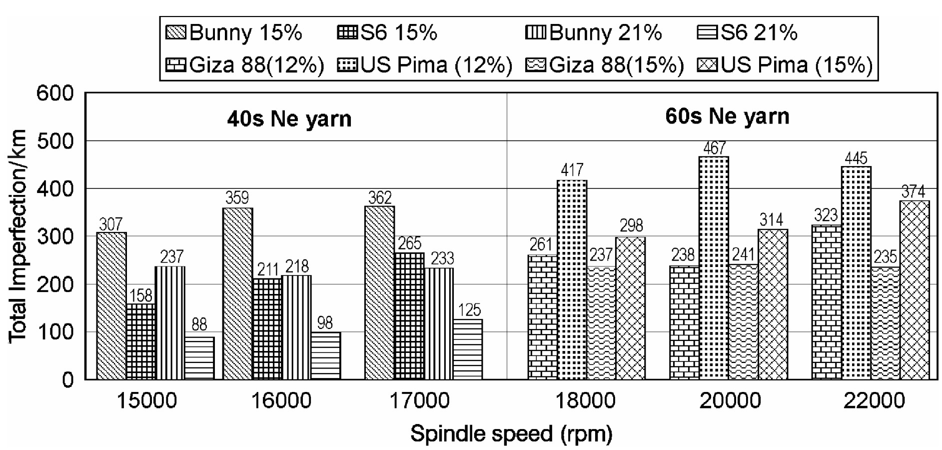

Fig. 4 —Imperfections of yarns

Table 2—Yarn imperfections for US PIMA and GIZA 88 cottons
[TM – 4.28]

Standard level of imperfection	Imperfections/km																	
	18000rpm						20000rpm						22000rpm					
	60s Ne		80s Ne		100s Ne		60s Ne		80s Ne		100		60s Ne		80s Ne		100s Ne	
	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88	US PIMA	GIZA 88
Noil – 12%																		
-50%	42	68	88	148	288	214	54	34	129	73	308	235	58	86	119	78	306	345
+50%	175	84	289	195	386	267	198	102	294	195	415	268	180	116	277	177	416	302
+200%	200	109	292	249	539	334	215	102	326	238	535	323	207	121	335	254	551	427
Total	417	261	669	592	1213	815	467	238	749	506	1258	826	445	323	731	509	1273	1074
Noil – 15%																		
-50%	28	40	103	90	167	201	30	35	118	103	233	239	52	44	83	79	246	238
+50%	123	107	218	167	305	247	132	98	281	160	322	269	153	102	230	143	337	246
+200%	147	90	259	192	374	302	152	108	274	178	382	325	169	89	249	167	409	325
Total	298	237	580	449	846	750	314	241	673	441	937	833	374	235	562	389	992	809
Noil – 18%																		
-40%	606	432	767	654	1193	1267	656	401	1096	746	1412	1493	640	458	1040	825	1474	1346
+35%	884	691	1137	882	1314	1263	1066	690	1297	957	1478	1377	1018	696	1348	987	1460	1317
+140%	442	396	836	633	1221	1240	619	428	1081	802	1735	1377	547	388	972	826	1599	1340
Total	1932	1519	2740	2169	3728	3770	2341	1519	3474	2505	4625	4247	2205	1542	3360	2638	4533	4003

Table 3—Yarn imperfections and hairiness of S6 and Bunny cottons
[TM – 4.38 and Count – 40 Ne]

Yarn parameter	Imperfections /km																	
	15% Noil						18% Noil						21% Noil					
	15000rpm		16000rpm		17000rpm		15000rpm		16000rpm		17000rpm		15000rpm		16000rpm		17000rpm	
	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6	Bunny	S6
U%	10.97	11.69	11.22	12.02	11.45	12.20	10.93	11.21	11.32	11.58	11.01	11.81	11.07	10.98	10.87	11.17	10.99	11.19
CV%	13.91	14.74	14.24	15.18	14.53	15.45	13.85	14.13	14.46	14.58	13.96	14.96	14.01	13.82	13.77	14.07	13.90	14.12
-50%	5	17	5	48	14	85	5	12	5	22	7	37	6	7	4	7	7	8
+50%	110	75	127	83	126	97	87	54	111	65	97	66	89	40	83	44	83	52
+200%	192	66	227	80	[illegible]	83	168	53	179	68	183	62	142	41	131	47	143	65
Total	307	158	359	211	362	265	260	119	295	155	287	165	237	88	218	98	233	125
-40%	153	318	200	441	244	532	168	235	196	314	174	392	164	189	149	215	184	221
+35%	672	641	745	671	755	724	636	507	691	601	644	609	591	427	591	499	613	501
+140%	738	329	903	436	916	408	660	232	712	330	716	302	535	161	518	222	545	267
Total	1563	1288	1848	1548	1915	1664	1464	974	1599	1245	1534	1303	1290	777	1258	936	1342	989
H	5.07	4.88	4.92	4.79	4.99	4.77	5.13	4.67	5.13	4.67	4.86	4.64	4.55	4.69	4.72	4.74	4.56	4.80
Sh	1.20	1.21	1.13	1.17	1.14	1.13	1.20	1.12	1.18	1.12	1.09	1.10	1.05	1.12	1.11	1.14	1.04	1.14
S3	1450	2175	1210.0	1738	1129	1412.1	1507	2032	1214.4	1923	1043	1674.0	1060	2124	1426	2140	1459.6	1843.8

Similar trends are also observed for the yarns produced from S6 and Bunny cottons (Table 3). S6 and Bunny have similar fibre properties except propensity values, which may be the reason for the differences in yarn properties (Fig. 4).

4 Conclusions

The instrument developed by SITRA will help the mills in assessing the fibre processing propensity, which, in turn, will help in producing yarn of optimum quality from a given fibre. The yarns produced from high propensity value cottons produce higher imperfections if same process parameters are used.

Acknowledgement

The author is thankful to the Department of Science and Technology, Ministry of Science & Technology, Govt. of India, for sponsoring the project. The thanks are also due to Ms. Indra Doraiswamy, Advisor, SITRA, for her valuable suggestions, provided during the preparation of the report and to the staff of Spinning and Physics Divisions for providing help in conducting the trials.

References

1 El Mogahzy Y, Broughton R & Wang Q, *Int Nonwovens J*, 7 (1) (1995) 26-33.

2 El Mogahzy Y, Broughton R & Wang Q, *Int Nonwovens J*, 6(4) (1994) 35-42.

3 Artzt P & Schreiber O, *Melliand Textilber Int*, 3 (4) (1974) 224-230.

4 *Standard Test Methods for Elastic Properties of Textile Fibres, ASTM D1774-94* (American Society for Testing and Materials).

5 Belegolovstsev S D & Surkova T A, *Tech Text Ind, USSR*, (5) (1971) 33-38.

6 Behery H, *Fibre/machine interaction*, paper presented at the Engineered Fibre Selection Research Forum (Cotton Incorporated, Raleigh, NC), 1988.

7 El Mogahzy Y, Broughton R & Guo H, *Text Res J*, 68 (11) (1998) 835-840.

8 El Mogahzy Y, Broughton R, Guo H & Rollins C, *Text Res J*, 68 (12) (1998) 907-912.

9 Basu A, Friction of fibre and yarn, *SITRA Focus*, 18(5) (January 2001).