INFLUENCE OF FIBER QUALITY ON DRAFTOMETER MEASUREMENTS

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Abstract

Fiber-to-fiber and fiber-to-machine friction play an important role in determining textile processing efficiency and end-product quality. A process, known as drafting, is used to control the attenuation of the fiber mass being processed in carding, drawing and spinning. The amount of attenuation the fiber mass is subjected to can be referred to as the "draft". Critical draft is the draft at which drafting forces become unstable; also known as "stick-slip". Prior studies have shown that the break draft on ring spinning frames should be 10 percent below critical draft. Textile processors have the option to control the stick-slip point without altering the break draft on the spinning frame by altering the twist in roving. Critical draft can be determined through instruments such as the ITT Draftometer. In this study, cottons of various fiber qualities (length and micronaire) were converted into roving and measured on the draftometer. Roving was produced at the recommended level of twist as well as at higher and lower levels of twist and then subjected to spinning trials to measure yarn quality and spinning efficiency.

Introduction

Spinning mills have a need to produce yarn that reaches the target quality in as efficient a manner as possible. Researchers often discuss the "processability" of fibers into yarn. One goal of determining "processability" is the relatively simple measurement of yarn quality; however another aspect of "processability" is processing efficiency. During spinning the newly formed yarn may break, a state known as an "end down". When the yarn end is down in rotor spinning the spin box ceases operation and awaits repair by the piecer, which is generally an automated process. In ring spinning, however, an end down results in roving continuing to be fed to the nip of the roll and going directly into the waste. In addition to this material loss, on top of the loss of yarn production, an end down in ring spinning must be manually pieced up. The so-called "piecings" that occur from the yarn being pieced up must be removed during winding and clearing. There are several potential causes of ends down during spinning: non-lint content, hard ends and lapped ends. Hard ends are segments of roving which do not draft properly, therefore a large mass of fiber exits the nip of the roller at once and the yarn breaks. Hard ends can be minimized via proper construction of the roving. Properly constructed roving will be uniform in mass and will result in a more uniform (lower CV%) and more efficiently produced (fewer ends down) yarn.

Fiber processing equipment is set up using fiber quality parameters, such as those derived from the HVI or AFIS type instruments. In general, fiber length is the most important factor in setting roll spacings; however other parameters such as micronaire come into consideration due to fiber fineness, desired yarn size and other factors. From the card through the spinning frame, a process known as drafting is used to control the attenuation of the fiber mass. The "draft" is the amount of attenuation the fiber mass is being subjected to and can happen in one stage or multiple stages depending on the configuration of the machinery. When multiple stages of drafting are occurring, such as on a draw frame or spinning frame, draft distribution is an important consideration to control overall quality. Draft distribution is the way in which the total amount of draft is distributed across the drafting zones. Another factor to consider is "critical draft". Critical draft is the draft at which drafting forces become unstable; also known as "stick-slip".

The research presented focuses on the construction of roving to minimize hard ends and maximize yarn quality by controlling draft. In ring spinning the total draft, from roving to yarn, takes place in two zones. The first drafting zone is known as the break draft. Break draft is not always easily changed on spinning frames and most spinning mills have the break draft essentially permanently selected on each ring frame. To produce various size yarns the roving size can be altered and the front draft can be altered while leaving the break draft alone. Prior studies by ITT (Institute of Textile Technology, Raleigh, NC) have shown that break draft on ring spinning frames should be 10% below critical draft (McCreight, et al, 1997). As previously stated, break draft may not be easily set, so an alternative option is to alter the twist of the roving to manipulate the critical draft. Critical draft can be determined through instruments such as the ITT Draftometer (Feil, 1982). To investigate the role of fiber quality parameter on drafting forces a selection of cottons with a diverse range of properties was processed into roving and spun into yarn. Roving was constructed based on draftometer measurements to represent a wide range of twist/critical draft. The yarn quality and spinning efficiency was analyzed to relate fiber quality parameters to draftometer measurements.

Materials and Methods

Five cotton bales were selected for processing based on fiber quality parameters tested on an HVI 1000 (Uster Technologies, Knoxville, TN) and an AFIS Pro (Uster Technologies, Charlotte, NC). The selected cottons (Table 1) had a wide range of micronaire, length, short fiber content and fineness.

Table 1. Fiber properties of bales selected for processing.

	HVI				AFIS			
Cotton	Mic	UHML	UI	Strength	UQL	SFC(w)	Fineness	Maturity
1	3.2	1.18	81.6	27.1	1.27	10.7	153	0.90
2	4.6	1.10	81.6	25.0	1.13	10.9	182	0.93
3	4.8	1.10	80.4	26.7	1.16	12.1	169	0.93
4	4.5	1.22	83.1	31.5	1.32	6.2	174	0.99
5	4.0	1.13	82.7	28.6	1.21	7.8	166	0.95

Each cotton was processed in full bale quantity at 100 lbs/hr on a Truetzschler DK803 card (Monchengladbach, Germany) into 70 gr/yd sliver. Two passes of drawing on Reiter RSB drawframes was used to produce a finisher sliver of 70 gr/yd for conversion to 1 hank roving on a Zinser 660 roving frame (Schlafhorst, Germany). Roving was tested on a draftometer (Figure 1) based on the ITT Draftometer design. Critical draft was determined using the draftometer and an optimum twist was selected for each cotton based on the critical draft – 10% determination. Six additional sets of roving were produced using 1,2 and 3 additional toothed gears and 1, 2, and 3 fewer toothed gears to create seven twist levels in the roving for spinning. Spinning was carried out on a 160 spindle Zinser 321 ring frame using a twist multiple of 3.8 and a spindle speed of 16,000 rpm to produce a total of 480 packages of Ne 30/1 yarn per roving construction. Ends down were recorded during spinning by spindle position, time and type of ends down (hard end, foreign matter or lapped end). Yarn quality was assessed using an Uster Tester 4 (Charlotte, NC) on 20 packages at 1,000 yds per package tested and an Uster Tensorpaid 4 (Charlotte, NC) for strength testing on 20 packages with 20 breaks per package.

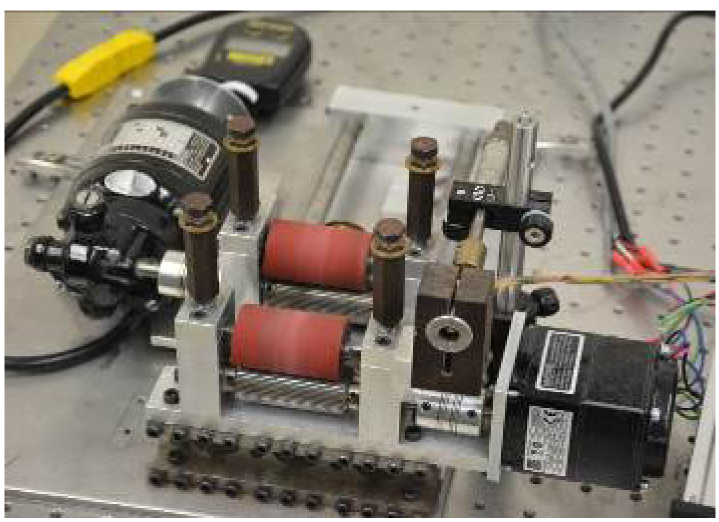

Figure 1. Draftometer used to measure drafting forces.

The draftometer consists of a simple 2 roller single draft zone apparatus in which the rear roller is variable speed to allow variation in the draft while the front roller is equipped with a Schaevitz transducer to monitor and record the front roll deflection caused by drafting forces. Hard ends cause greater deflection in the position of the front roll and can be detected by the transducer. As twist is increased in the roving the drafting forces increase, as twist is decreased the drafting forces decrease and therefore less force is exerted on the fibers. Each roving was tested for up to 10 minutes to inspect for hard ends, such as the blue spikes in Figure 2.

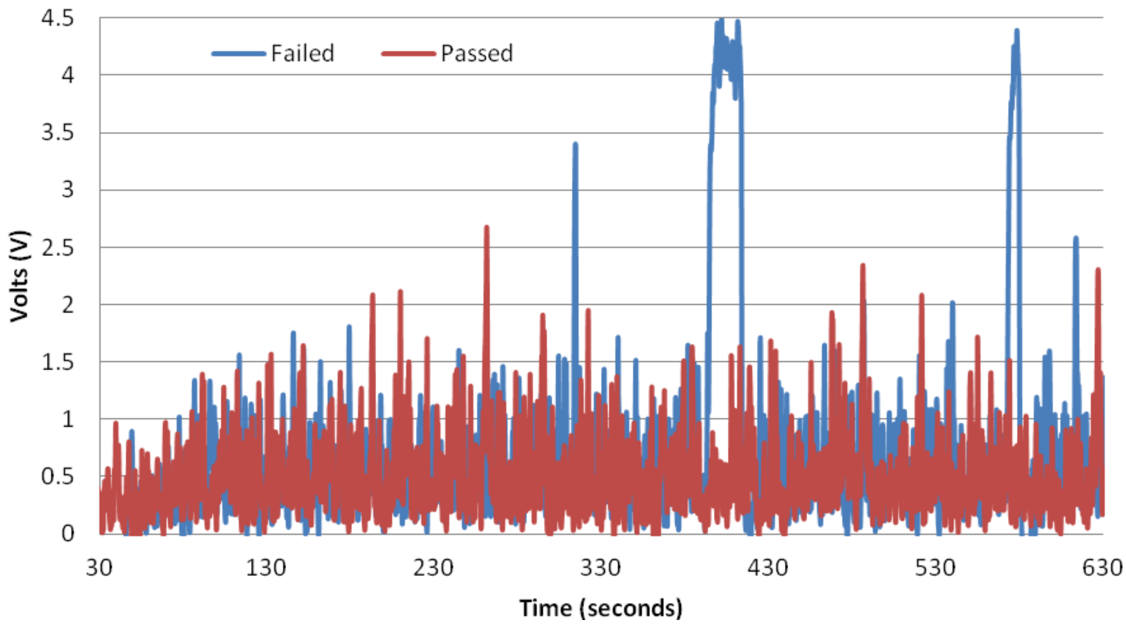

Figure 2. Draftometer results for an acceptable and failing roving

Results and Discussion

The five cottons were processed and tested on the draftometer in order to identify the optimum twist level for 1 hank roving (Table 2). There was no apparent relationship between the fiber properties of the five cottons (Table 1) and the draftometer results. The spinning efficiency, as related to ends down caused by hard ends, is illustrated in Figure 3. As the twist gear increases in tooth count the turns per inch in the roving decreases. It is readily apparent that as twist decreases, the number of hard ends decreases as well. Critical draft, as shown in the figures, is the critical draft -10% guidance from ITT. The roving with slightly less twist than the optimum guidance from ITT had even fewer hard ends, however if twist is too low the yarn quality will suffer.

Table 2. Draftometer results and roving frame twist settings for the five cottons

Cotton	Twist Gear	Twist Multiple
1	38	1.33
2	32	1.58
3	31	1.63
4	38	1.33
5	38	1.33

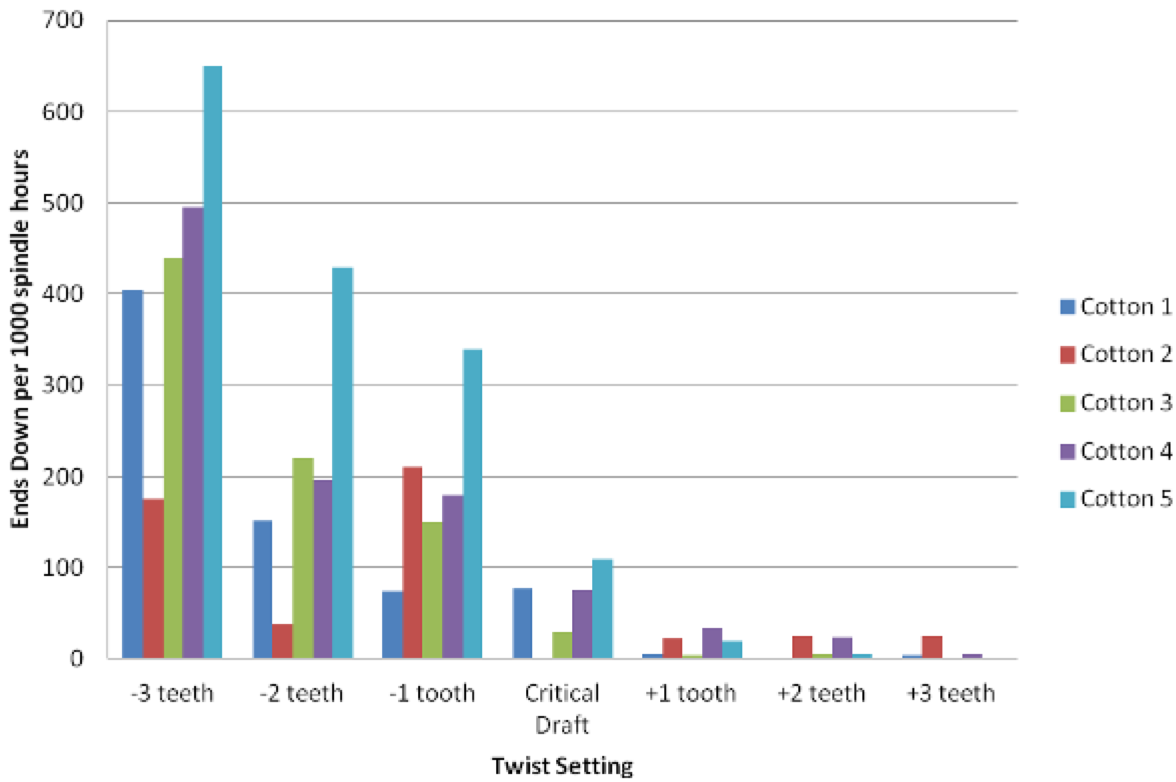

Figure 3. Ends down as related to twist gear.

Yarn mass uniformity (CV%) (Figure 4) appears to be optimum at the point of ITT guidance or with one additional tooth in the gear. As twist decreases past that point the uniformity rapidly diminished (increasing coefficient of variation for yarn mass). Yarn strength (Figure 5) also appears to be optimum when the twist was set per ITT guidance.

Roving frames, unlike spinning frames, generally consist of two rows of spindles, a front row and back row, with different spinning geometry for the two rows. The different spinning geometry translates into differences in spinning tension which can result in slightly different draftometer measurements for packages produced on different rows. The results in Figures 4 and 5 would suggest that when the two rows give slightly different results, the operator should err on the side of less twist rather than increased twist. The ends down data in Figure 3 shows a drastic increase in ends down when twist was increased by even one tooth.

Conclusions

Surprisingly, no relationship was readily apparent between fiber properties and draftometer measurements. Further work is needed to assess the -10% recommendation of ITT, as the yarn quality was extremely similar with slightly less twist and the ends down were even lower with less twist. However, it is readily apparent that with too little twist in the roving, there comes a point where the lack of control of the fiber results in greatly reduced yarn quality. It is understood that tension changes in the roving package as the package size grows and the diameter increases. More work is needed to assess the impact of package size on draftometer measurements.

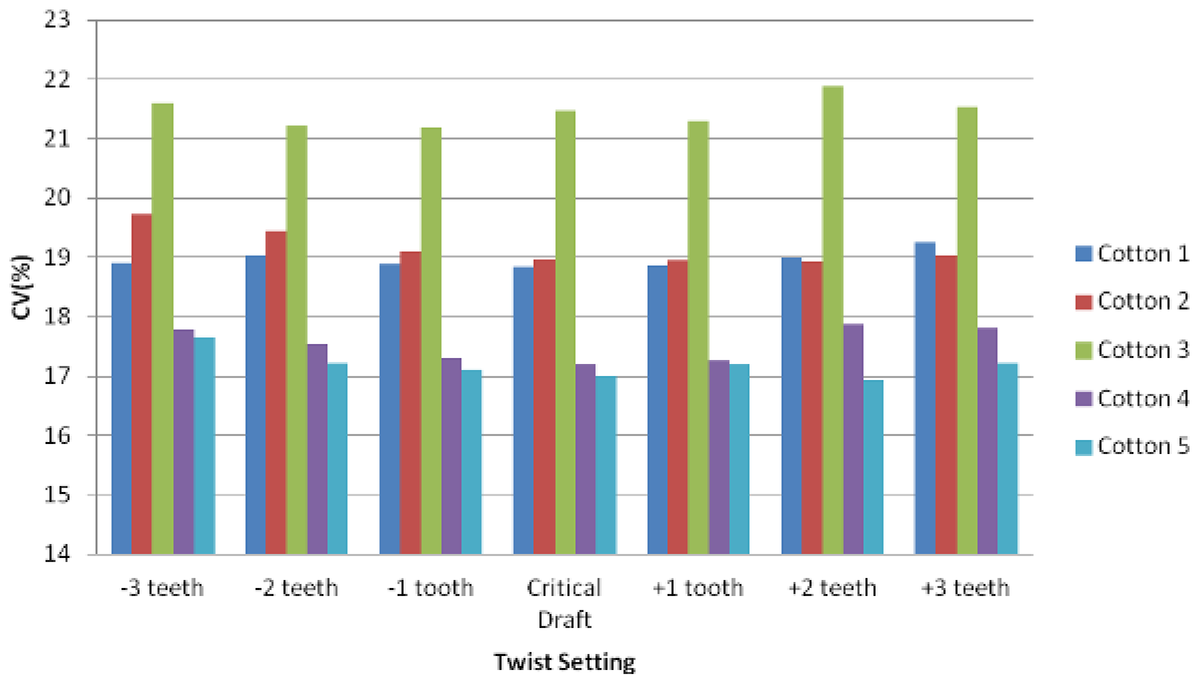

Figure 4. Yarn mass uniformity (CV%) as related to twist gear.

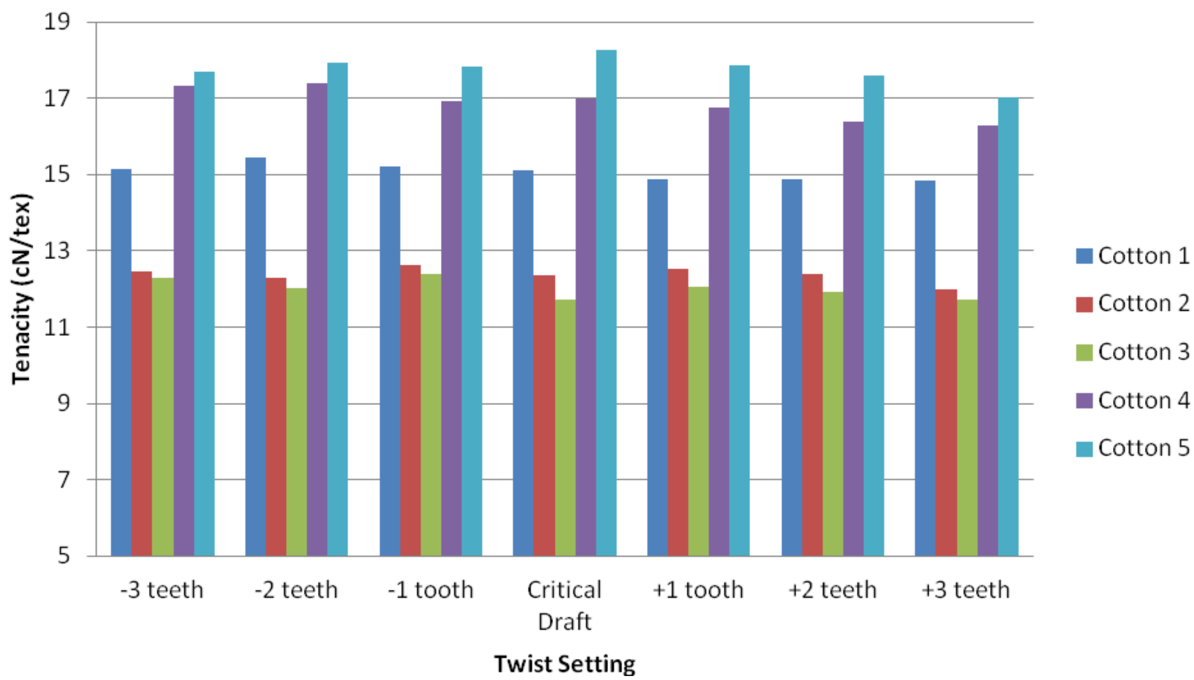

Figure 5. Yarn strength as related to twist gear.

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References

Feil, R. 1982. Comparison of certain draft systems and the effects of certain draft element settings, and break draft levels as determined by Draftometer measurements, on quality of polyester/cotton ring-spun yarns. Institute of Textile Technology. Charlottesville, VA.

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