UTILIZATION OF FIBER DRAFTING TO ASSESS SURFACE FRICTION

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Abstract

In order to assess the impact of fiber surface properties upon resultant yarn quality, a device capable of measuring inter-fiber friction relatively quickly and accurately is desirable. The present work is an attempt to utilize a single-zone roller drafting system to measure the drafting force of a roving assembly as a function of variable parameters including relative humidity and fiber ageing. A single cotton variety was spun into roving and tested for draft force under variable humidity conditions and also as a function of fiber ageing. Results indicate that as relative humidity increases, inter-fiber friction also increases, leading to a concomitant increase in the break draft that can potentially be used to spin yarn. This in turn may lead to methodologies by which finer count yarns may be produced from a given cotton without adverse effects upon yarn imperfections, thus leading to added value of the yarn.

Introduction

Roller drafting is the most common method used for achieving sliver attenuation for subsequent yarn formation. During the drafting process, fibers are pulled across each other via application of differential speeds between the two drafting rolls. The applied force required to enable fibers to slide past each other in a sliver or roving assembly is termed the drafting force. Drafting force may be affected by instrumental settings such as the distance between draft rolls, and the pressure applied to the draft rolls in order to grip the fibers in the nip point. Physical characteristics of the fibers themselves also affect draft force, including fiber fineness, fiber length, and fiber crimp. Variability in draft force may lead to processing inefficiencies such as ends down and yarn unevenness. The purpose of the present work is to determine whether fiber surface chemical properties have a significant effect upon draft force and draft force variability. The methods chosen to elicit surface chemical changes are an accelerated ageing protocol in addition to changing the relative humidity under which the fibers are being drafted.

Materials and Methods

The draftometer utilizes a fixed speed front roll that is mounted on a cantilever assembly. The back roll speed is variable but lower than the front roll speed, and it is mounted on a sliding plate to enable distance changes between draft rolls. Also mounted on the front roll cantilever assembly is a Linear Variable Differential Transformer (LVDT), so that when the cantilever is displaced by the force acting upon the roving the distance is measured by the LVDT and transformed to a force measurement.

20 bobbins of 1 H roving from a single variety of cotton were made, each with 1.30 TPI. 10 bobbins were used as control and 10 bobbins subjected to accelerated ageing at 60^{o}C, 80% RH for 5 days. Subsequent to ageing, all 20 bobbins were sequentially conditioned at 35%, 45%, 55%, 65% and 75% RH. At each RH, 2 control and 2 aged bobbins were analyzed on the draftometer with a fixed roll spacing of 70mm. At each RH, samples of roving were also analyzed for % moisture, pH, glucose, fructose, and L*a*b* color.

Results and Discussion

Analysis of fiber color and surface chemicals, shown in Table 1, shows that the accelerated ageing of cotton leads to significant changes in each of the measured parameters. In addition, a plot of fiber moisture content as a function of

Table 1. Affect of Accelerated Ageing on Fiber Chemical and Color Characteristics. Numbers in brackets denote SD.

	pH	Glucose (%)	Fructose(%)	L*	a*	b*
No Age	6.31 (0.03)	0.090 (0.004)	0.070 (0.002)	92.89 (0.16)	1.11 (0.07)	8.93 (0.21)
Aged	6.12 (0.04)	0.070 (0.003)	0.055 (0.009)	92.37 (0.02)	1.36 (0.02)	10.18 (0.01)

relative humidity, as shown in Figure 1, indicates that fiber moisture content increases with the relative humidity, with the implication of a possible effect upon fiber friction.

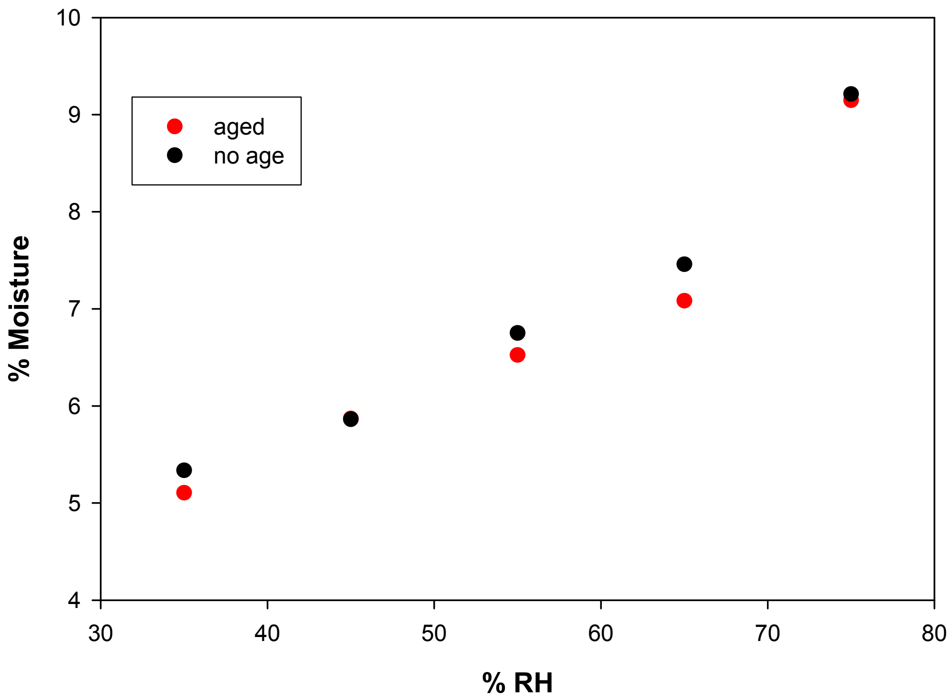

Figure 1. Fiber Moisture Content as a Function of Relative Humidity

To determine the effects of relative humidity upon draft force measurement, rovings were drafted at each RH level using a series of progressively larger draft ratios, as seen in Figure 2. As the draft ratio increases from 1.10 to 1.32 at each RH, the draft force becomes progressively larger. The apparent cause for this behavior is that, since roving has an applied twist, as the draft ratio becomes larger the roving experiences a compaction which in turn brings the fibers into closer proximity to each other, resulting in an increasing draft force. Further, as RH is increased, the measured drafting force becomes larger, indicating that increased RH results in an increase of surface moisture which acts to increase hydrogen bonding between fibers.

The region from 1.3 to 1.4 draft ratio is dominated by a transition from the static friction behavior seen from 1.1 to 1.3 to a "stick-slip" behavior that is accompanied by an increase in draft force variability. This region is referred to as the critical draft zone. As noted from Figure 2, however, behavior in this region is also dependent upon RH. As RH increases, the point at which draft force variability increases is moved to higher draft ratio. The possible implication of this behavior is that it may be possible to achieve higher yarn counts with no increases in imperfections by performing the spinning operation under higher controlled RH conditions. In the present case, for instance, at RH = 65%, a stable break draft is found between 1.19 and 1.25, while at RH = 75% the stable break draft is between 1.32 and 1.40, suggesting that a higher total draft at yarn spinning may be achieved at RH = 75%.

The region from 1.4 to 1.8 in Figure 2 is associated primarily with dynamic friction forces between the fibers in the roving. No significant effects are observed due to changes in RH.

Figure 3 shows the relationship between draft ratio and draft force at 75% RH as a function of accelerated ageing of the fiber. No shift in critical draft is observed as is the case with changes in RH, but a significant decrease in draft force is observed after ageing. This shift is presumably due to one or more of the observed chemical changes (Table 1) as a result of accelerated ageing. The lowering of draft force as a result of ageing may potentially have an effect upon subsequent yarn quality, and this will be the subject of future investigation.

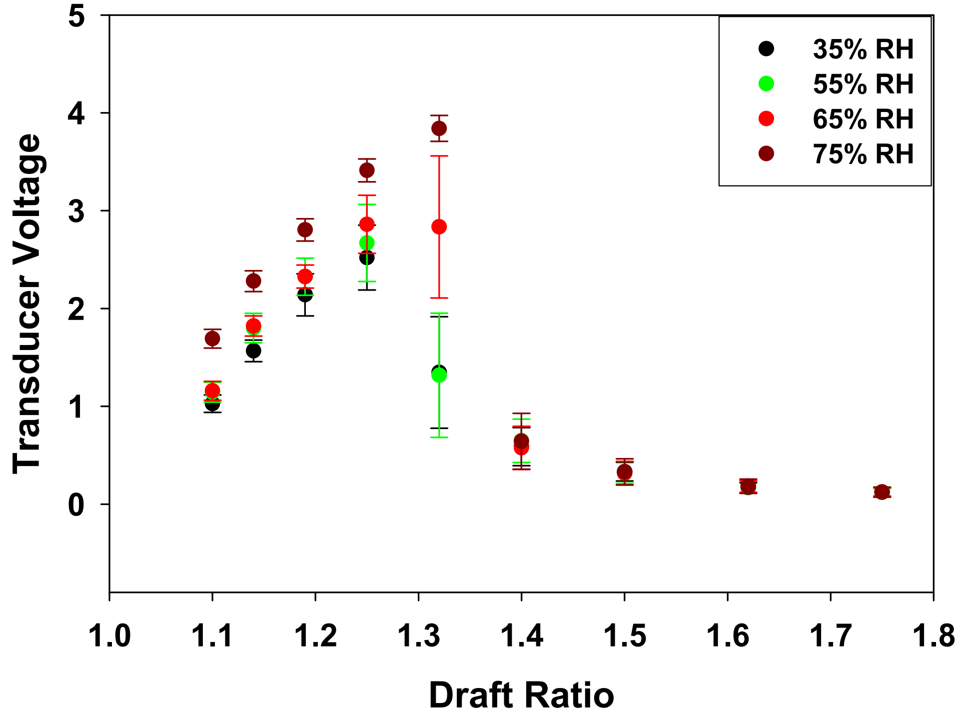

Figure 2. Relationship Between Draft Ratio and Draft Force as
A Function of Fiber Moisture Content (RH)

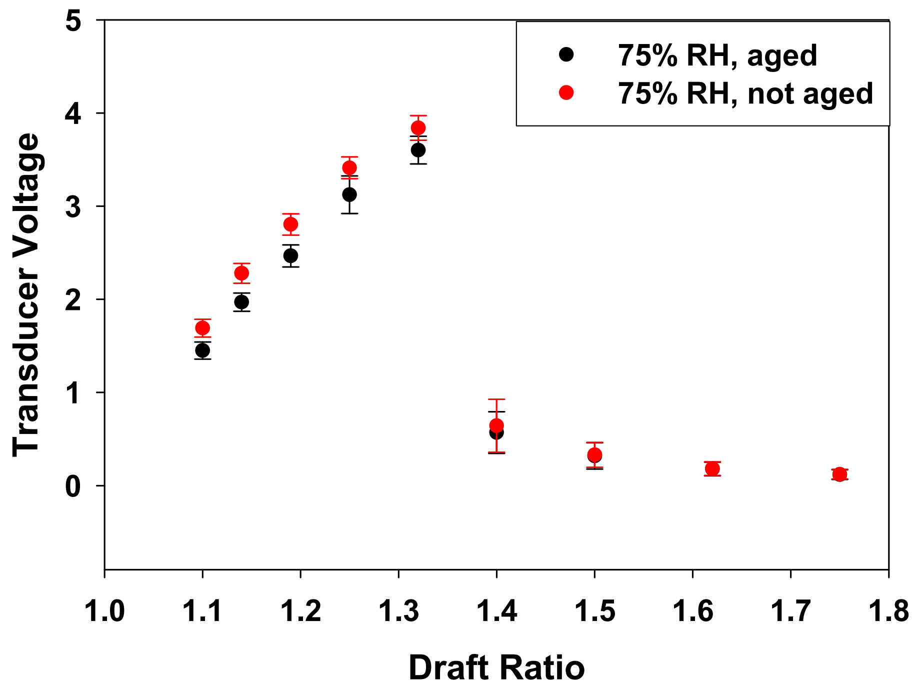

Figure 3. Relationship Between Draft Ratio and Draft Force as
A Function of Fiber Ageing

Summary

Drafting forces between fibers in a roving structure appear to be partially a function of the surface chemical constituents found on the fiber. Successive increases in relative humidity lead to successive increases in drafting force, as well as a shift in the critical draft region where static and dynamic friction forces both play a role. Accelerated ageing of the fiber also leads to measurable changes in drafting forces, although no effect upon the critical draft zone was observed. The implication that increasing RH may lead to the ability to spin higher yarn counts with no adverse effect upon yarn quality will be explored in subsequent work.