MASS DETERMINATION OF THE COTTON LENGTH FIBROGRAM

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Abstract

The test specimen used by the high volume instruments is a beard sample. Theoretically it is possible to determine the length of each fiber in the test beard. To better understand the length distribution of fibers scanned by the HVI, fibrograms from the instrument were compared with those constructed from Suter-Webb array determinations. Some possible reasons for the lack of agreement between these fibrograms were explored. As the distance moved from the thin tip of this tapered beard toward its thick base increases, so does the difficulty increase of determining the lengths of the fibers that compose the beard.

Introduction

For the proper utilization of a cotton during textile processing, it is important to know the length characteristics of the cotton. The effective length of cotton is determined by establishing its staple or High Volume Instrument (HVI) Upper-Half-Mean (UHM) length during the classing process. Traditionally the staple was established by a classer. Currently the staple is characterized by the HVI classing systems. The HVI do an excellent job of determining the staple length of cottons. However, each cotton is the composite of long, medium and short fibers. A length distribution exists on each cotton seed. This distribution is modified toward the shorter lengths during the separation and cleaning processes at the gin. Because of the increased demands placed on fiber by newest textile equipment, it is important to know more about the length distribution of cotton than was previously necessary.

Background

Ideally it should be possible to compute the number and length of fibers which compose the fibrogram sensed by the HVIs (Hertel, 1940). An idealized cotton length distribution is presented in Figure 1. The dotted line represents the fibrogram sensed by the HVI. The staple length is determined from this curve. Differentiating this fibrogram twice yields the length-frequency distribution by mass that is indicated by the solid line. This form of the length data is the easiest to interpret. Given the length-frequency distribution it should be possible to calibrate the HVI length measurements to this distribution instead of the two points, the UHM length and uniformity index, currently used. Unfortunately, several challenges exist to making accurate determinations of the mass or of the number of fibers in a HVI test beard. Such determinations near the base of the test specimen are particularly difficult to obtain. One reason is the holding length required for the test specimen. A second is the instruments beginning of scan. The test beard is currently scanned to approximately four mm of the holding comb. The holding length at the base of the sample and the beginning of the scan restricts access to the absolute base of the specimen. Figure 2 shows these effects through an idealized model. The gray fibers approximately represent the amount of the specimen that is not sensed by the instrument. Figure 3 illustrates the results of these phenomena. The mass at the absolute base of the sample is not that which is currently determined by the HVIs. Air gaps are present in the specimen between the needles that hold the fibers. These air gaps discourage the scanning near the face of the specimen holder. The unmeasured specimen mass makes the determination of the shortest fibers particularly difficult. Approximately 25 percent of the mass of the HVI test beard is not being sensed or thoroughly evaluated. However, these phenomena do not affect the determination a cotton=s staple length. When the HVI is calibrated this omitted length is accounted for. However, the HVI mean length is not the mean length of the total specimen, but the mean length of the included fiber.

A second complicating factor is that the fibrogram theory is number based. I feel it is the mass of a beard not the number of fibers that is sensed during HVI testing. For certain the individual fibers are not being counted as they are by the Zellweger-Uster AFIS instrument. Fiber mass is definitely related to the number of fibers, but what is the form of the relationship? The individual cotton fibers are not straight or cylindrical. They are crimped and tapered. It has been suggested the HVI test specimen is length biased. Could this be the same as saying that if you multiply the number of fibers by their respective lengths you have a good estimate of the length distribution by mass? It has also been suggested that the optical mass determined by the light transmission systems may not be totally linearly related with the gravimetric mass of the beard.

As mentioned before, it would be very useful to have information about the total length distribution of the cotton fibers. The density function for cotton is not yet defined. It would be useful to know the distribution and its major parameters. Such information could change the way we currently consider cotton length.

Objective

The overall purpose of this study was to consider the mass of the fibrogram near its base region. Another objective was to determine the number of fibers and their linear densities, throughout the length frequency distribution, of several representative Upland cottons. A third purpose was to consider the rationale for the HVI test specimen being a

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length biased sample (Morton, W. E. and J. W. S. Hearle, 1962).

Method and Equipment

A remanufactured Zellweger-Uster 900B/C was used to obtain the HVI fibrograms for six Upland cottons. Suter-Webb arrays were performed on the cottons by three technicians to obtain data for constructing fibrograms for the comparisons. The number of fibers in each category of the arrays were counted manually for construction of the fibrograms by number. The mass of the fibers were determined on a Sartorius MC5 balance. These data were analyzed using least square regression techniques (Steel, R. G. D. and J. H. Torrie, 1980). Lotus SmartSuite software was used for the statistical calculations, construction of the figures, and preparation of the manuscript.

Results

Careful control of the thickness or heaviness of the HVI cotton beard improves the repeatability of fiber length measurements. However, some differences in fibrograms were observed within the range of approx-imately 200 optical units. The three fibrograms presented in Figure 4 are for the same cotton at three different base amounts. There is a weak but significant trend for heavier beards to be more uniform in length. For the 30 base amounts tested, r=0.47 and was significant at the 0.01 level of confidence. The implications of these results are presented in Figure 5. The total optical amount was determined by summing the amounts for every fourth step along the fibrogram. The weight compared with the total optical amount is the mass of the broken specimen beyond step four of the fibrogram. This relationship between weight and amount showed a slight non-linearity. This non-linearity would affect the length fibrogram. It would likely result in the under estimation of the mass of the long fibers and the over estimation of the mass of the short fibers. The linear densities of six cottons are presented in Figure 6. The linear densities of the shortest fibers for each cotton are two to three times higher than those for the other lengths. When the fibers shorter than 1.6 mm are ignored the linear density distributions shown in Figure 7 are obtained. The modal or most frequent length fibers are the ones of the highest linear density. The results presented in Figure 8 are very interesting. The dotted line represents the group average. For this line, r=0.97 and is significant at the 0.001 level of confidence. To verify the observed trend another set of arrays for the same cottons were performed. The fibers for each array length category were weighed and counted. These results are shown in Figure 9. The dotted line is the same line shown in Figure 8. The second set of data agrees well with the first set of data. These data shows that gravimetric weight is a function of length.

Figure 10 illustrates some of the difficulties encountered while working with fibrograms. When the numbers of fibers for a cotton are multiplied by their lengths and summed or integrated twice on length, the resulting fibrogram is different from the one sensed by the HVI system. The sensed fibrogram is actually positioned between the second and third accumulations. Figure 11 illustrates the relationship between the mass and number of fibers when considering fibrograms. The lower solid curve is the fibrogram sensed by the instrument. The dashed and the solid gray lines represent the number*length and mass fibrograms respectively. The result of dividing the second derivative of a fibrogram by length is shown by the gray dotted line in Figure 12. These effects are illustrated for a cotton in Figure 13. The solid lines represent the sensed and the dotted lines represent the adjusted data. As an additional example, the number of fibers in the Suter-Webb array specimen for a cotton is shown in Figure 14 by the dark solid line. The numbers of fibers were then multiplied by their lengths to obtain the dotted gray line. Its shape is a saw toothed pattern because the counts were for 1.59 mm increments. Figure 15 illustrates how the second derivative of the sensed fibrogram divided fiber by length that is represented by the solid dark line agrees more closely with the number of fibers than does the second derivative of the fibrogram represented by the light dashed line. The same type data for another cotton is shown in Figure 16 for another cotton.

Discussion

Long staple cottons tend to have a higher HVI uniformity ratio than short staple cottons. On average, longer staple cottons also tend to load slightly heavier on the fibrograph comb. For the series of cottons obtained at incremented base amounts, there was also a trend toward increased uniformity with higher base amounts. Since it was not possible to match fibrograms constructed from comb-sorter data with those sensed by the HVI, it was entertaining to explore the effects a nonlinear response might have on fibrograms. This is not just a question of different thickness' of the beard at their bases, but each tapered test specimen is composed of a range of thickness'. The test HVIs optical response was roughly linear with mass. However, for the exercise, it was treated as a quadratic response. A linear response was approximated by picking a point near the center of the curve and extending to zero. The differences in the two responses shifted the length distribution toward the shorter fibers and lowered the uniformity of the sample. This difference was not great enough to explain the inability to match the constructed and sensed fibrograms.

Each cotton is composed of a is range of linear densities. Some linter or fuzz fibers are apparently also removed from the seed during ginning. It is doubtful whether any of these fuzz fibers would survive additional cleaning, carding, and make their way into yarn. The distribution of finenesses did not suggest the observed relationship between fiber mass and length. The weight of a fiber appears on average to be approximately a linear function of its length. The curvature shown for linear density versus length apparently is not a significant factor. The linearity of the relationship between average weight of a fiber and its length was confirmed by counting and weighing fibers from of a second Suter-Webb array for the cottons.

Applying the observed relationship between mass and length, it could be argued that the fibrograph specimen may not be length biased as suggested. The fibrograms would be the same for the mass and the length*number distributions. The division of the fibrogram by the associated lengths changes the shape of the length-frequency distribution. The data is skewed toward the shorter fibers and therefore agrees more closely with the by number distribution.

Conclusion

There are many difficulties in trying to match sensed and constructed fibrograms. The idea of the comb specimen being length biased appears to be questionable. That the specimen mass is a linear function of length might be a better explanation. The fibrogram examples are far from perfect, but they do support the idea of a by number distribution. Apparently for a combination of reasons the sensed fibrograms do not fully agree with constructed ones. It also appears that one should use caution when using lengths other than the UHM from sensed fibrograms. A transformation could possibly be used to bring the HVI data into agreement with the comb-sorter data.

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Disclaimer

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