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IMPROVED FMT PRECISION WITH NEW SAMPLE INSERTION TECHNIQUE

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Abstract

In order to generate the most meaningful data, the Fineness and Maturity Tester (FMT) must be as precise as possible. A new mechanical device has been developed to insert the sample into the chamber of the FMT that has resulted in improved precision compared to an existing mechanical tool. Advantages of the new insertion device include the ability to reuse a sample. With greater precision of FMT data the amount of cotton consumed in the analysis is reduced since a smaller number of replications are needed to arrive at mean values with less uncertainty. The new device helps to retain the original cylindrical dimensions of the sample after compression in the FMT sample chamber by inducing lines of crimp equally spaced and parallel around the major axis of the cylinder. After compression, the lines of crimp are transformed into zigzag patterns like miniature springs. After the compressed sample is allowed to "bloom", the zigzag pattern is transformed back to straight lines of crimp.

Introduction

The Shirley Developments Limited Micromat Fineness and Maturity Tester (FMT, Micromat model) upgraded at SRRC has produced more accurate and precise data compared to before upgrading (Von Hoven et al., 2001 and 2002). Upgrading included sealing the system to prevent leaks, a leak detector module (LDM) to monitor leak status during routine operation, headspace resistance standards (HRS) to monitor airflow and detector calibration, and dozen new calibration cottons. The calibration cottons allowed calibration of the sample chamber volume so that the instrument readings, after applying a constant offset correction, fit Lord's original models (SDL 089 Manual, 1994).

The FMT measures fineness and maturity based on air permeability through a fixed mass of compressed fibers. Differential pressures are the quantities measured. The initial stage of compression is referred to as PL for low pressure and the second stage compression is referred to as PH, for high pressure. Units for PL and PH are in mm of water. The mechanically cleaned cottons are placed manually in the sample chamber. Fineness and maturity are calculated from PL and PH readings by appropriate empirical equations.

Whether using the FMT as a means of grading cotton for fineness and maturity or using it to calibrate another testing device, good precision is necessary. In the interest of time, the fewest number of sample replications needed to generate statistically sound data are desirable.

Another approach to improved precision is based on retesting the specimen by the FMT. This has the advantage of reducing the amount of sample needed as check cottons for quality control purposes during routine analysis. Previous attempts were not promising (Montalvo, unpublished data). Compared to the initial test data, the retests produced less precise information.

A review of the literature revealed that no one had investigated the compressional behavior of the cotton specimen in the sample chamber. It is plausible that the optimum precision of FMT data – initial and retests – can only be obtained by an understanding of the phenomena that influences the pressure drop when air is drawn through the compressed fiber material.

In a recent paper (Montalvo et al., 2002), it was suggested that the initial stage of compression (PL) in FMT operation initiates the fiber contact process by establishing the relative portion between adjacent fibers. As a consequence, the same frequency of PL and PH (second stage compression), operator-induced outliers were found in the data. To obtain the best precision, it was necessary to remove the outliers from the database prior to obtaining average values.

In the current study, the important element of compressional behavior of fiber assemblies was introduced to incorporate knowledge to a new FMT sample preparation procedure, to improve precision, and to test a new mechanical device, which allows insertion of the sample into the chamber. Advantages include better precision, the ability to retest a sample and the elimination of operator induced outliers.

Materials and Methods

A new means of sample presentation was investigated using an upgraded Shirley Developments Ltd. Micromat FMT calibrated by a constant offset technique (Von Hoven et. al., 2001, 2002). For two cottons, with micronaires of 5.55 and 3.27, six replications of four-gram fiber samples were carded by using Louete cotton hand cards with 100 picks per inch. The carded sample was then rolled into a cylinder with a diameter of approximately 2 inches and a length of approximately 5 inches. The sliver was inserted into the FMT chamber using the old mechanical method with a pronged mechanical device, (Montalvo et al., 2000), and the new wire insertion device. Operators handled the cotton only to weigh the sample and place it on the cards.

The prong and wire devices are shown in Figure 1. In order to study the operator effect on the procedure, two operators tested both cottons. In determining if the same samples could be retested, each operator tested six replications of each of the high and low micronaire cottons, stored the samples in tubes, Figure 2, for one week. Then the same samples were retested in the same order and in the same direction as in the first testing with the same end placed in the chamber first. This procedure was followed again for a second rerun of the samples. The tubes were stored horizontally to reduce the effects of gravity.

Results and Discussion

Elements of Compressional Behavior

The more important elements of compressional behavior of fiber assemblies (Beil and Roberts, 2000) that are pertinent to the current study include: hysteresis, irrecoverable compression, viscoelastic effect, crimp, and induced orientation. In the case of hysteresis, it was observed that there was a distinct loss in length of the cylindrical sample in the FMT chamber and significant changes in PL and PH readings occurred when the same specimen was inserted in rapid succession. This may be due to a viscoelastic effect and irrecoverable compression in the chamber.

By allowing at least one week for a tested sample to "bloom" before retests were conducted, the original length of the cylindrical (sliver) sample along with the initial PL and PH readings were fully recoverable. Between retests, the samples were stored horizontally in tubes to minimize the effects of gravity on the blooming process. Retesting of a sample is useful for research purposes, to understand the effects of compression, as well as for quality control purposes. While performing routing analysis, check cottons could be added throughout the testing to ensure the machine is giving the proper measurements. By being able to retest a sample twice, this reduces the amount of check cotton needed.

The new wire insertion device induces linear crimp equally spaced and parallel around the main axis of the sliver that is inserted into the chamber. During compression in the chamber these localized areas of highly crimped fibers absorb more energy as they are compressed. Immediately after compression, the lines of crimp resemble zigzag patterns. After blooming, the crimp pattern is transformed back to straight lines of crimp. These lines of crimp probably help to retain the original dimensions of the sliver sample after compression in the FMT chamber. Also, the lines of crimp help to prevent the carded sample that was rolled into a cylinder from unrolling.

In the case of induced orientation, the carded sample introduces fiber orientation in the sliver as opposed to random orientation in a grab sample (Montalvo et al., 2002). During compression, the fibers are oriented more horizontally rather than randomly. This allows for fiber slippage to occur during compression, which tends to slow down the blooming process, since the fibers become more entangled. It is not surprising that the blooming process takes at least one week to retain full recovery of the initial instrument readings.

FMT Results

By reducing the coefficient of variation of the FMT PL and PH measurements of the replications the calculated micronaire, maturity and fineness values also are more precise. One advantage to greater precision is a potential reduction in the number of replications needed in testing. Also desirable is the absence of an operator effect with the improved precision. For this reason, the ratios of properties of one operator to the other should be one for the mean of six replications for both cottons. Finally, if samples are to be rerun, mean property ratios of the original run of the sample to the rerun of the sample should be one.

When manually inserting the sample into the FMT, the operator typically uses his or her fingers resulting in differences between operators. In an attempt to standardize the sample insertion method, two techniques were studied, the pronged tool and the wire device, Figure 1. The pronged tool is comprised of 4 slender wires about 1 inch long fanned out from an 8 inch metal tube. The operator then pushes the sample down into the chamber, working in a helical manner, pushing a bit more of the sample into the chamber with each motion of the pronged tool. The wire device contains 12 18-inch long wires arranged in a 1-inch diameter circle. To load the sample, the wires are twisted with a disk to form a cone with a diameter of approximately 6 inches, and the sample is dropped into the device, Figure 1. The wires are permitted to return to their 1-inch circle, surrounding the sample. The device is then turned upside down and placed into the chamber. The disk is pushed down until it remains at the top of the chamber to keep the sample in the chamber while the wires are being retracted.

Two cottons, a 5.55 and a 3.27 micronaire, were used in this study, each with six replications. Figure 3 demonstrates the reduced coefficients of variation in PL and PH FMT measurements of two cottons for samples inserted with the wire device and with the pronged tool. This reduction is believed to be from the more homogenous manner in which the sample is inserted into the chamber with the wire device rather than with the pronged tool. Undoubtedly, there are other contributing factors as discussed in the above section of this paper. The wire insertion procedure permits retention of fiber orientation. During compression of the carded cylinder, the induced fiber orientation is more uniform at the lines of crimp and this provides more energy at equally spaced intervals around the cylinder.

Figures 4 and 5 show the coefficients of variation of the two cottons inserted by both methods and by both operators for maturity and fineness, respectively. For two operators and two trials, the coding in both figures is as follows: Op1-1 (operator 1, trial 1), Op1-2 (operator 1, trial 2), Op2-1 (operator 2, trial 1), and Op2-2 (operator 2, trial 2). The CVs for the samples inserted with the wire device were lower than those inserted with the prong tool for the majority of fineness and maturity measurements.

Figures 6 and 7 are based on the wire insertion method only. In Figure 6, to show that the sample can be reused, an FMT tested specimen was stored in a 2.5-inch diameter tube for one week. The Y-axis gives the ratio of the means of six replications, original to the rerun samples. Each cluster of cells contains four bars: across two operators and the high and low micronaire cottons. The ratios are all within 0.987 to 1.0075. These values are not practically different from one, demonstrating the feasibility of reusing a sample in the FMT by the wire insertion method.

Another demonstration to show that the samples can be reused by the wire insertion method is illustrated in Figure7. In this case, an FMT tested specimen was stored in the tube for one week, inserted, stored again in the tube for one week and again retested. The ratios are plotted as measured by one operator to another. The coding in the figure for micronaire sample is as follows: Mic (original test), Mic re (first retest), and Mic-re2 (second retest).

The range of ratios were as follows: micronaire, 0.985 to 1.002, maturity, 0.96 to 0.992, fineness 0.998 to 1.04. For the low micronaire cotton, these preliminary data suggest that the ratios for all these fiber properties are converging very close to one. For the high micronaire there is no clear trend. Additional studies are planned with two-week intervals between retests.

Conclusions

Based on the reduction of coefficients of variation by changing insertion methods, the wire insert is a more precise means of presenting the sample to the FMT. This reduction is seen in the FMT measurements, PL and PH, as well as in the calculated maturity and fineness. Fiber property ratios of the initial and second rerun sample to the original run sample were not practically different from one indicating the same specimen can be rerun, and rerun again. This indicates that specimens can be rerun, thus saving cotton. In addition, fiber property ratios of operator one to operator two were within 4% of unity, thus there is no apparent operator effect on the cotton samples.

References

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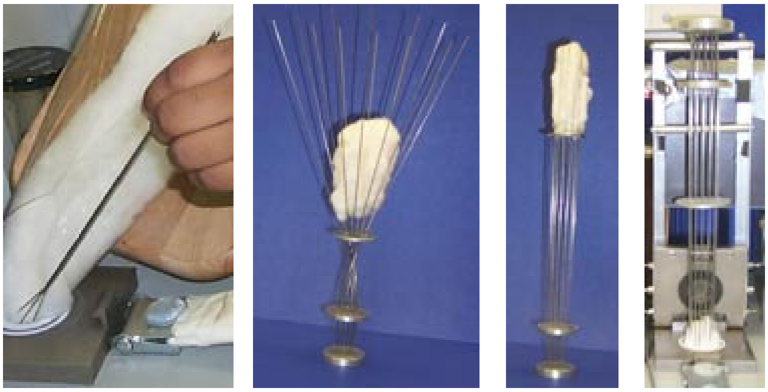

Figure 1. Pronged mechanical device, left, Wire insertion device, with cotton, center, and inserting sample into FMT, right.

Figure 2. Six FMT replications stored in tubes.

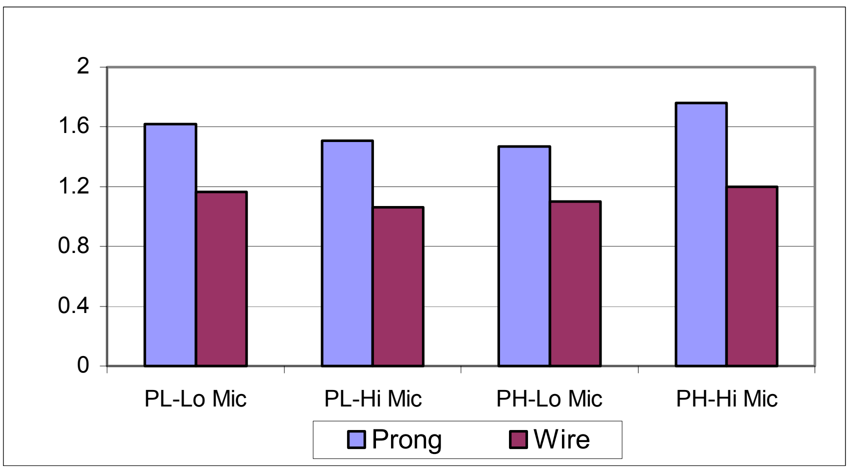

Figure 3. Insertion Methods Compared: CVs (%) of PL and PH of Hi and Lo Mic cotton.

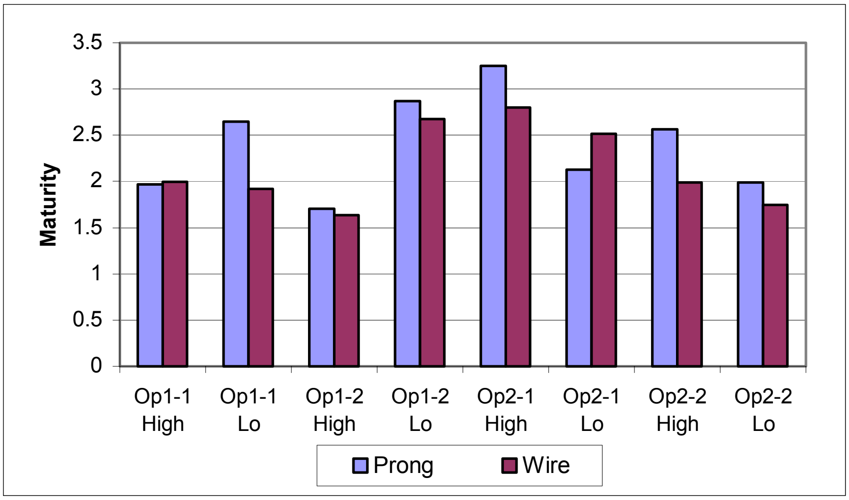

Figure 4. Insertion Methods Compared: CVs (%) for Maturity of Hi and Lo Mic cotton, two operators.

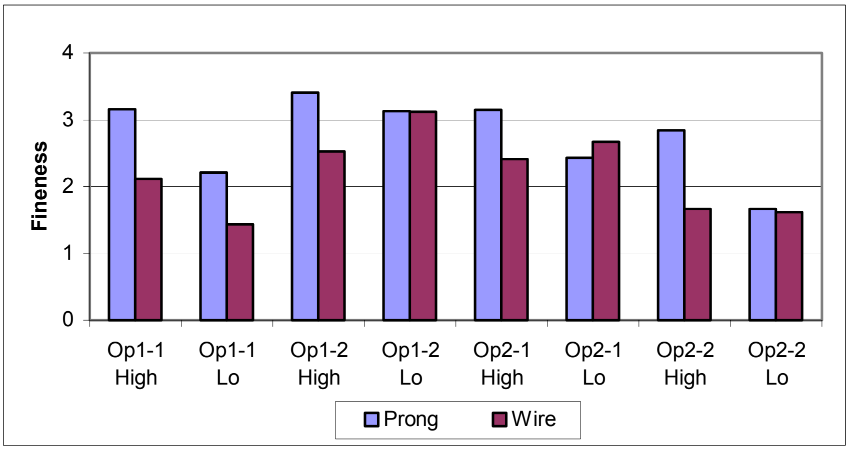

Figure 5. Insertion Methods Compared: CVs(%) for Fineness of Hi and Lo Mic cotton, two operators.

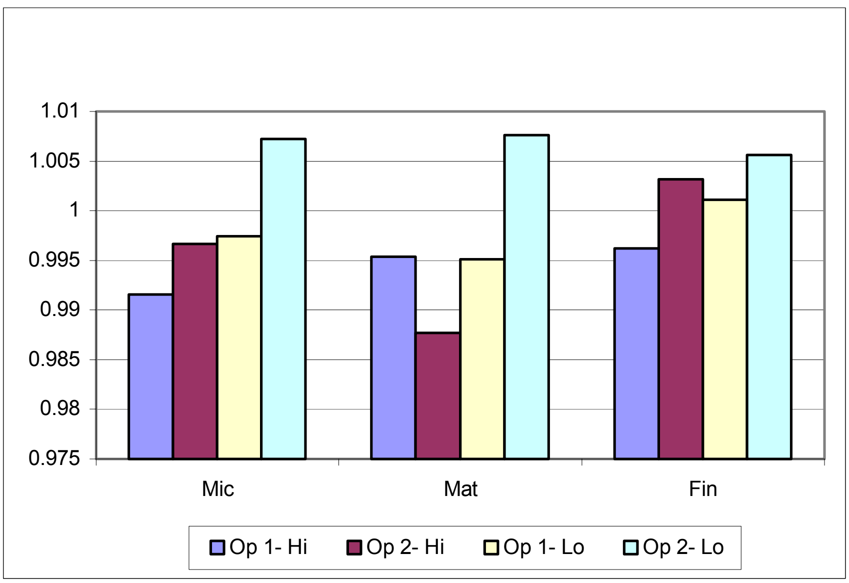

Figure 6. Ratio of Means of 6 Reps of Original to Rerun Samples.

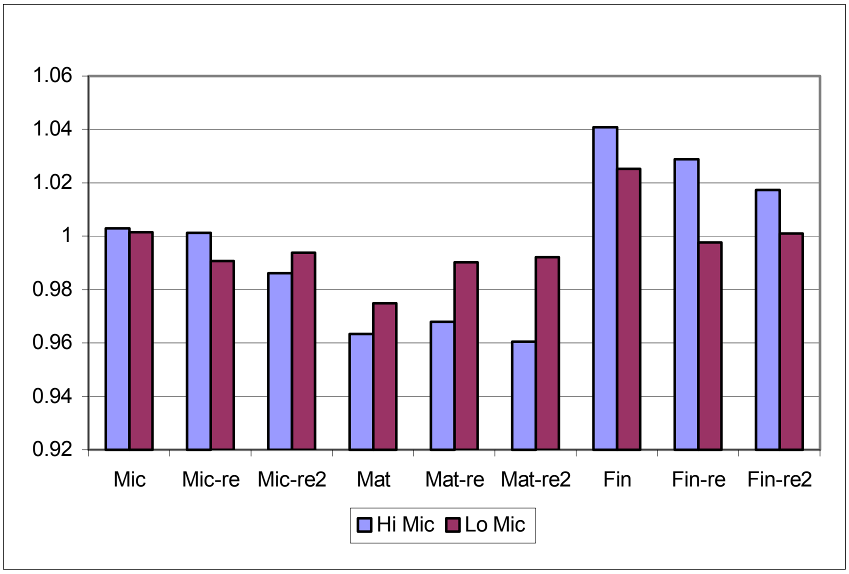

Figure 7. Ratio of Means of 6 Reps of Operator 1 to Operator.