QUANTILE MODELING OF YARN STRENGTH DISTRIBUTION

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Abstract

Yarn tensile properties, i.e., strength, elongation and energy to break, are typically measured using dynamometric instruments that provide estimates of mean values with some measure of variability of each parameter. Those measures are typically used to compare and rank samples obtained from different cottons or using different processing conditions. However, simple comparison and ranking methods do not provide sufficient information with regard to the manner in which the variation in fiber properties or in processing conditions impact the distribution of yarn strength. Yet, the difference in the distribution shape, precisely at the left tail of the distribution (low strength segments) is what really matters when it comes to predicting and ranking yarn performance in downstream processing.

Probability distributions can differ in such varied ways that one or two summary statistics, such as the mean and standard deviation, are often inadequate when complex distribution shifts and distortions occur. In this research, we examined the use of a graphical method (Chambers *et al.,* 1983) to compare the distributions of two yarn strength datasets, i.e. an empirical Quantile-Quantile plot (Q-Q plot).

An empirical Quantile-Quantile plot is a graphical method used to enhance numerical statistical analyses. This method allows a much more detailed comparison (over the entire range of the distributions) between two sets of observations by giving distributional details that are not provided by typical numerical statistics. For instance, empirical Quantile-Quantile plots allow deciding whether a simple summarization of the relationship between the distributions is appropriate. If the distributions differ in a complex way (for example by different shifts in two or more regions of the distributions), the empirical Q-Q plot will be very helpful in visualizing and explaining the difference.

Q-Q plots are constructed by plotting the quantiles of one empirical distribution against the corresponding quantiles of the other distribution (Chambers *et al.,* 1983; Krifa *et al.,* 2001). If the two data sets are noted as x_i , $(i=1 \text{ to } n)$ and y_j, $(j=1 \text{ to } m)$, the Quantile-Quantile plot is constructed from the $Qy(p)$ and $Qx(p)$ coordinate points, with $0 \leq p \leq 1$.The medians of the two distributions constitute the coordinates $(Qx(0.5), Qy(0.5))$ of a point on the Quantile-Quantile plot. The same applies for the quartiles and for all the quantiles of the two distributions.

The method was used to compare strength distributions of yarns spun from the same cottons on a conventional ring spinning frame and on a compact ring spinning frame. Results show that although simple variance and mean comparisons unquestionably lead to the conclusion that compact yarns are stronger, the use of empirical Q-Q plots shows that for most cottons tested, the differences in strength distributions are more complex than what the comparison of summary parameters would reveal. Most interestingly, some cottons showed significantly higher strength values with compact spinning when examining the summary parameters. However, examination of the Q-Q plots revealed that those differences were mainly due to a shift at the high end of the strength distribution, and that conventional and compact yarns spun from these cottons had virtually equal strength values at the lower end of the distribution. Thus, for these cottons, compact spinning did not affect the lower part of the strength spectrum and thus, is not likely to result in any improvement of yarn mechanical performance when subjected to tensile stresses in downstream processing. Further analysis is underway in order to determine the underlying phenomena and the fiber properties that are at the source of these differences.

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References

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