QUANTIFYING NEP GENERATION IN COTTON PROCESSING

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Abstract

Neps (tight and dense entanglements of fibers) are among the most disruptive structures found in cotton lint. Neps are formed due to mechanical handling of the fiber during harvesting, ginning and textile processing. Nep generation potential varies among cottons having different fiber properties and different processing histories. This paper presents results from ongoing research aiming at characterizing and quantifying neps generation behavior of diverse cottons, in order to explore potential for nep prevention along the cotton production and processing chain.

Introduction

During the harvesting, ginning and cleaning processes, cotton fibers are exposed to varying degrees of mechanical processing intensity. The intended effects of mechanical processing are usually opening, cleaning, nep removal and organizing the fibers into a linear structure. Other effects are unintended and usually include nep formation and fiber breakage (Robert and Blanchard, 1997; Krifa, 2004, 2006; Krifa and Hequet, 2005).

There is general agreement that neps are affected by most mechanical processing stages in the cotton production chain. Neps are created when fibers become tangled in the process of harvesting, ginning and other operations. They can cause difficulty for mills and detract from the appearance of yarns and fabrics (Davidonis, 2003). Souther (1954) observed that the majority of neps were created within the ginning process; subsequent operations such as opening and cleaning almost doubled the amount of those neps. Mangialardi (1985) found that the gin machinery affected nep content, with the gin stand and saw cylinder lint cleaners being the major contributors to the formation of neps. In addition to nep generation, the successive stages of the cotton processing chain incrementally inflict fiber fatigue and the accumulated fiber breakage increases the amount of short fibers.

Nep creation and fiber breakage are relevant to cottons with wide ranges of fiber properties. It was found in previous research that the extent to which different cottons are affected by these phenomena varies (Cantu et al., 2007; Krifa, 2004; 2006). The primary objective of this research is to explore and quantify this variability in the cotton behavior when submitted to successive mechanical processing.

Materials and Methods

In order to quantify nep generation through successive mechanical handling, samples were obtained from forty stripper-harvested and saw-ginned bales. The samples were processed through a SDL laboratory fiber blender and opener. The opener simulates many industrial processes which combine opening and waste ejection using centrifugal force. The opener was modified to prevent waste ejection and thus ensure that all neps created are quantified.

A total of 220 samples were obtained from the 40 cotton bales. The 220 samples were put through a varied number of opening passages (from zero to five) in order to represent increasing mechanical handling of the cotton lint. The samples were then tested on the AFIS (3 replications with 3000 fibers each) for neps and individual fiber properties. Instrument calibration was checked daily, the samples were conditioned in the laboratory at 65% relative humidity and 21˚C (standard laboratory conditions) for at least 48 hours before testing.

Results and Analysis

AFIS data was used to derive a nep-generation curve relating the number of neps to the degree of mechanical damage (the number of opening passages). Based on the fits obtained, the plots were separated into three categories according to the cottons: linear pattern, curvilinear pattern, and flat pattern showing no significant relationship between the number of neps and the extent of mechanical processing. Examples of the three patterns observed are shown in Figures 1, 2 and 3, respectively.

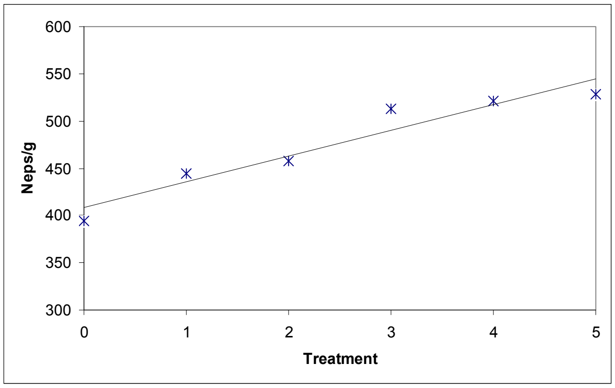

Figure 1: Nep generation curve – Linear pattern

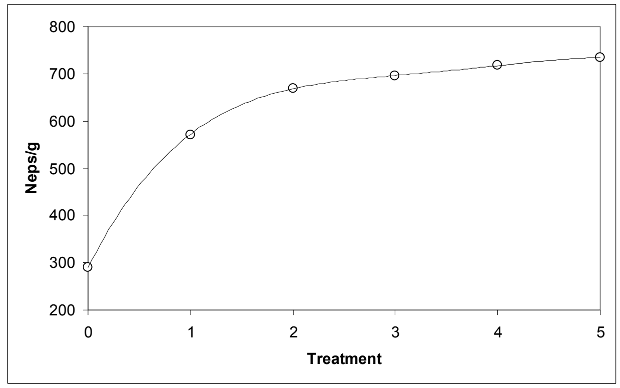

Figure 2: Nep generation curve – Curvilinear pattern

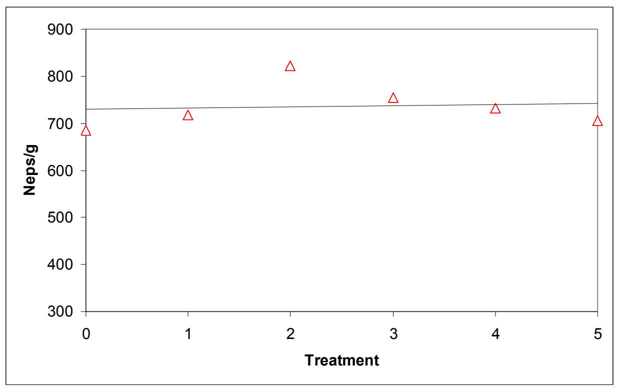

Figure 3: Nep generation curve – Flat pattern

Figure 1 depicts the linear trend which illustrates a linear increase of the number of neps with the number of opening passages. Figure is illustrative of the non-linear trends observed and shows an increase in the number of neps after 2 to 3 opening passages. Processing the lint beyond three passages resulted in no sizeable further increase in the number of neps. Finally, Figure 3 shows the third pattern observed, i.e., flat trend, which shows a virtually constant number of neps regardless of the number of opening passages (with some fluctuation).

The 3 curves above were grouped on Figure 4 in order to visualize the differences between the three patterns. It appears from this Figure that the linear pattern corresponds to the lowest amounts of neps and that the flat pattern is at the opposite extreme, while the curvilinear pattern lays in between the two. This ranking was generally observed on the majority of cottons tested in this research. It would appear from these results that the three patterns may correspond to three different stages in the neps creation process of the various cottons, with the flat pattern corresponding to the stage where all fibers that have the potential to tangle under the effect of mechanical handling have done so. The linear pattern would correspond to the early stages of the neps formation process (i.e., low nep counts increasing at a consistent rate), while the curvilinear pattern corresponds to the transition between the linear increase and the plateau in the nep formation process.

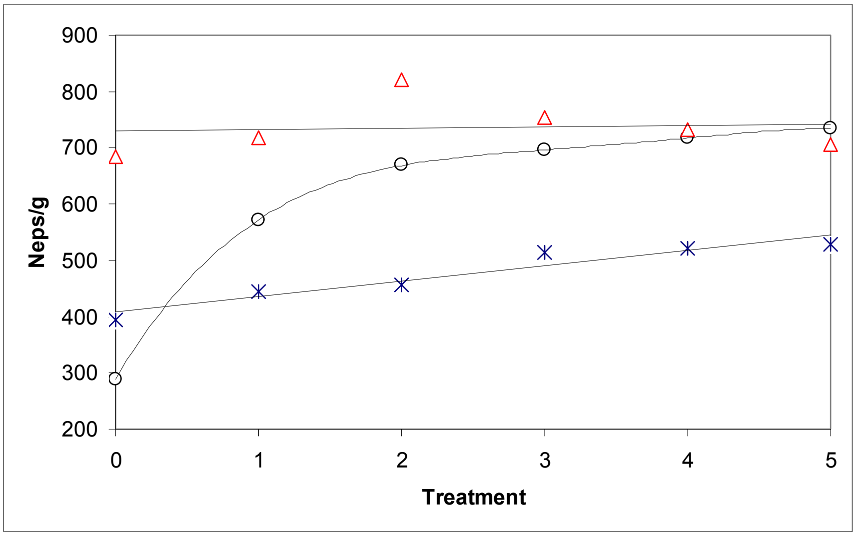

Figure 4: Nep generation curve, linear, non-linear, and flat patterns.

In order to explain this variability in behavior of the different cottons, i.e., why they exhibit the different patterns, we examined the variation of AFIS and HVI fiber properties across the three categories. Selected box-plots which showed significant discrimination between the three categories are represented in Figures 5 and 6.

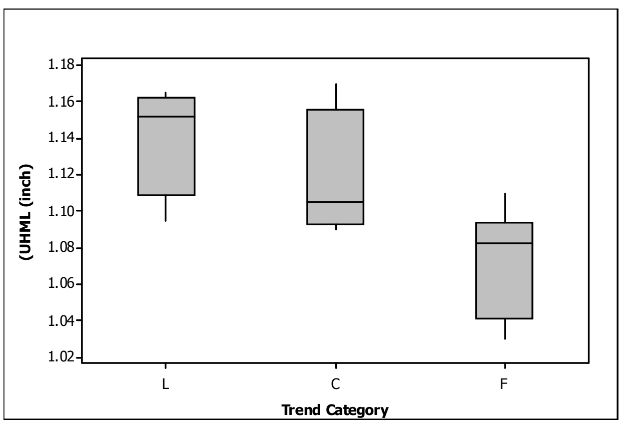

Figure 5: Length variation across regression categories (L: linear, C: curvilinear, F: flat)

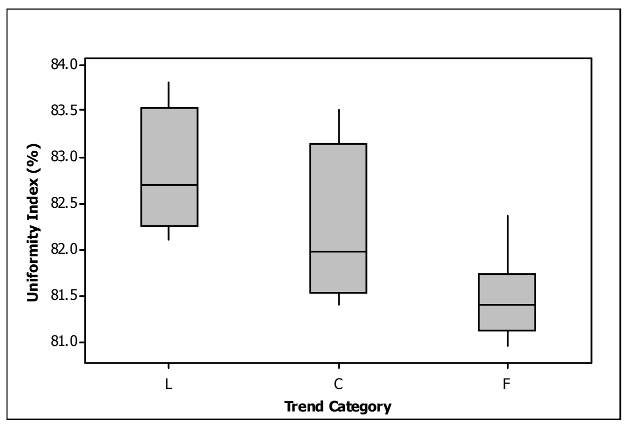

Figure 6: Uniformity variation across regression categories (L: linear, C: curvilinear, F: flat)

As seen in the figures above, two fiber properties stood out upon inspection of the box plots: the upper half mean length (UHML) and the length uniformity index. Figure 5 depicts the box-plot of UHML and shows that the cottons corresponding to the flat nep-curve pattern (F on the x-axis) are the shortest, while those corresponding to the linear pattern (L) are the longest. As for the curvilinear pattern (C), it is mostly constituted of samples that have lengths in between the other two categories, as shown by the median (with a slight overlap between the ranges of categories L and C). The uniformity index shown in Figure 6 exhibits the same ranking among the three categories.

In addition to length parameters, Maturity ratio was also of interest (Figure 7). Maturity is known to impact both length and neps potential because it determines the fibers resistance to breakage (Krifa, 2006) and tendency to tangle (Hebert, 1988). As seen on Figure 7, the linear and curvilinear categories (L and C) show overall comparable maturity levels with a slightly wider range for the curvilinear pattern. The "Flat" category on the other hand exhibits a sizably lower maturity ratio with a wider range.

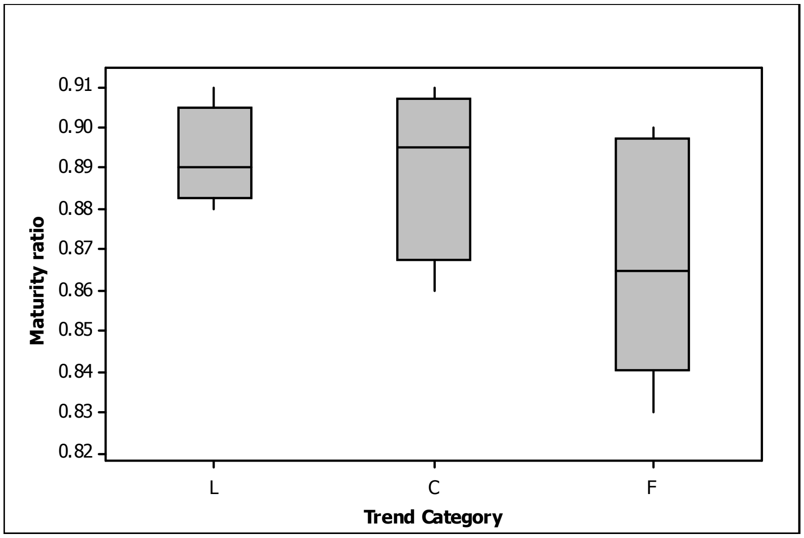

Figure 7: Maturity Ratio variation across regression categories (L: linear, C: curvilinear, F: flat)

It appears from these results that length parameters and neps generation potential are related. This relationship is likely to be due to the impact of mechanical aggressiveness on both length and neps. Thus, the linear neppines pattern would correspond to the cottons having undergone the least mechanical damage (the longest cottons) while the flat category would correspond to the cottons with the highest damage history, i.e., those that have reached the neps plateau and have the shortest length. Based on these observations, these two patterns (the linear and the plateau) may be two segments of a general curve that can be used to schematize the cotton neppiness behavior when submitted to mechanical damage. The curvilinear trend may in fact represent the general pattern of neps generation with increasing mechanical processing, as it captures both the linear zone (at limited mechanical damage) and the plateau zone (when mechanical damage is extensive).

Finally, fiber maturity determines the extent to which mechanical aggressiveness affects both length and neps. Thus, under similar processing conditions, immature cottons will incur more damage and will reach the neppiness plateau faster than mature cottons.

Conclusion

Neps generation with successive mechanical treatments was observed on a wide range of cottons with varied damage history. Different patterns were observed, with some cottons showing a linear increase in the number of neps with increasing mechanical processing, others showing a flat plateau with a constant number of neps regardless of the degree of processing and finally other cottons showing both trends with an increase in neps at the early stages of processing then a stabilization of the number of neps and the formation of a plateau beyond a certain degree of mechanical damage. The latter curvilinear behavior appears to represent the general pattern of neps generation. Further research is ongoing to further explore this pattern and determine a quantitative approach to discriminating between cottons with different nep generation potentials.

Acknowledgement

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