ИЗСЛЕДВАНЕ НА БИЕКТИВНИТЕ ЗАВИСИМОСТИ МЕЖДУ МЕХАНИЧНИТЕ СВОЙСТВА НА ПАМУЧНИ ВЛАКНА В ЕДИНИЧНО СЪСТОЯНИЕ И НА СНОП

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STUDY OF THE BIJECTIVE RELATIOSHIP BETWEEN THE SINGLE AND BUNDLE COTTON FIBER MECHANICAL PROPERTIES

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INTRODUCTION

The characterization of cotton fiber is very complex due to the growing and harvesting conditions of the cotton plant [1, 2]. It is very important for breeders to understand the relationships that may exist between specific fiber properties, overall fiber quality and yarn quality. All of these factors interact and are critical to the development of cottons that can compete in a global market. Understanding these interactions will allow breeders to more effectively use fiber data for selection purposes to improve yarn quality [3, 4, 5].

In this chapter, we will focus on the relationships between fibers' mechanical properties and yarns' ones by studying their relative behavior and the relationship between single and bundle cotton fibers.

APPROACH

The aim of the whole research is to elaborate a relationship between fibers' mechanical properties and yarns' ones by studying their relative behavior and the relationship between single and bundle cotton fibers. For this purpose, three different types of cotton fibers will be studied. These cottons were chosen from a list of twelve cottons covering a large panel of varieties and physical properties (maturity, fineness, micronaire, length, etc.) (***Figures 1 and 2***). Classifications per length classes and linear densities will be done in order to enlarge the scale when making plant selection. Analogical models will be presented for each length class for single and bundle fibers in order to provide additional information on their behavior. Properties evaluated will include elongation, single and bundle tenacities, work of rupture, etc. Bundle fibers quality will be an effective tool in predicting yarn quality and spinning performances.

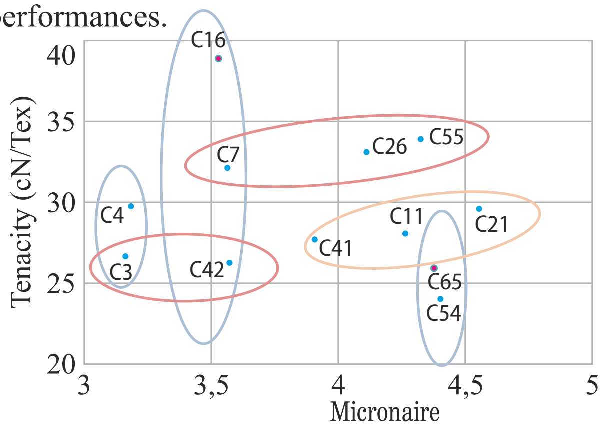

Figure 1 Tenacity vs. Micronaire for the 12 cottons

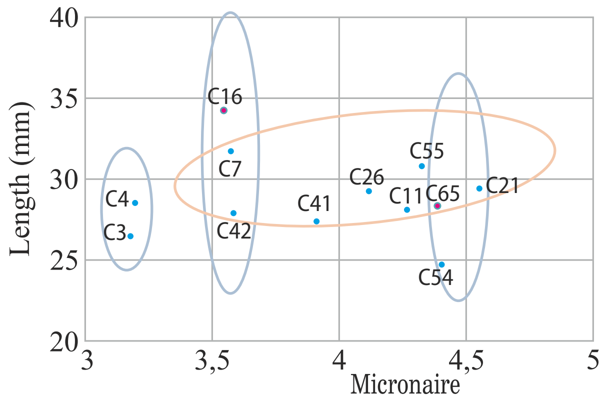

Figure 2 Length vs. Micronaire for the 12 cottons

Prior to testing, all cotton samples were conditioned for at least 48 hours in standard conditions (HR% = 65±4%, T = 20±2°C). A MTS Dynamometer machine (Tensile Strength Machine) was used for testing the fibers' single and bundle behavior after tensile, creep, relaxation and fatigue tests. In addition, FAVIMAT [6] was used for testing the tensile behavior of single fibers after determining their linear densities. Sensors used for the single and the bundle fibers testing were respectively 2N and 2kN. The gauge length used for all the tests was 15 mm and the tests have 5mm/min speed and 50mm/min respectively.

RESULTS AND DISCUSSIONS

After carrying tests with Favimat and MTS devices, data is processed with R [7] and RStudio softwares to draw the corresponding tests curves and to determine some other parameters such as:

➔ From the tensile tests:

- Work of rupture: The energy required to break a fiber determined by the area under the load-elongation curve;
- Extension at break: The percent change in fiber length at breaking force. It means how much the fiber will extend from its initial length for the break to finally occur;
- E: The initial modulus determined form the tangent of the initial stress-strain curve;

➔ From the creep tests:

- The viscosity determined from the creep test, it is equal to E.t where t is the intersection point of the two tangents;
- t: the creep time

Some results for single fiber creep tests of some samples are shown in 4.

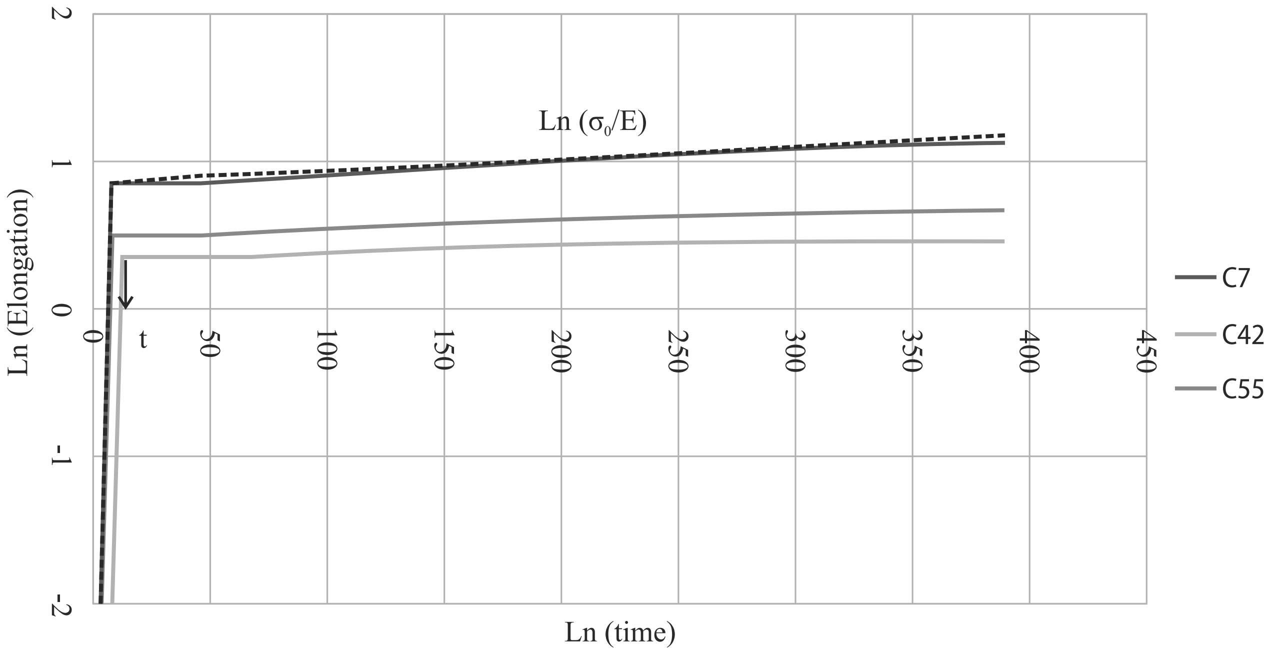

Figure 3 Single fiber creep test for cotton 7, 42 and 55

We can notice that the strain increased and asymptotically approached the value of Ln (σ0/E) (***Figure 3***) when t tended to infinity. The response of this model to an applied stress is characterized by a fast-increase part explained by the fact that the stress is at first carried entirely by the viscous element. The second part, characterized by a very slight increase explains the elastic element in the continuous elongation of the viscous element. The transition time between the two parts represents the creep time constant, t, which is equals to η/E. Where η is the viscosity and E is the Initial modulus given by the tensile test at a given constant rate of extension.

We concluded that the creep response was viscoelastic and therefore that we could apply a Kelvin- Voigt model in which a spring (representing the elastic element) and a dashpot (representing the viscous element) are connected in parallel (***Figure 4, Table I***).

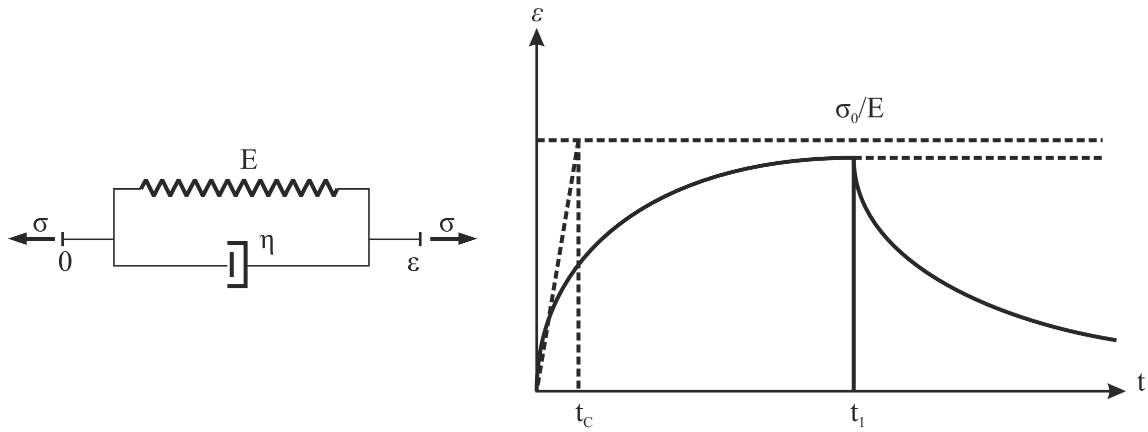

Figure 4 Kelvin Voigt model and response to creep test

Table I

Standard linear solid models [8]

Analogical model	Mechanical element	Analogical model	Mechanical element
σ ← 0 —E— ε → σ; $\sigma = E\varepsilon$	Spring	σ ← 0 —η— έ → σ; $\sigma = \eta\acute{\varepsilon}$	Dashpot

For bundle testing, the tests were carried out with a speed of 50 mm/min.

Data acquired from the tensile tests are:

- Load and Elongation at Peak
- Initial modulus
- Work of rupture

Evaluation and examination of cotton fibers tensile properties serves multiple purposes. The results obtained enable to estimate the performance of raw materials during the transformation procedures of fibers. It is also used to predict the tensile properties of spun yarns or woven textiles. Fiber bundle tensile tests can appear satisfying the objective because of their relationships with tensile properties of yarn. However, this relationship can be rapidly expected because in assemblies of parallel fibers factors such as the degree of fiber to fiber interactions, and twist contribute to fiber bundle strength.

Regarding creep tests results for bundles, we are working on finding the corresponding models of each cotton variety and comparing them with the single ones. We estimate puzzle out the bijective relationships existing between the two cotton fibers testing dispositions.

CONCLUSION

Creep tests have shown an analogical response. The other mechanical tests will be carried out for the rest of the samples in both single and bundle cases, in order to find the relationship between fibers and yarn structure taking all the phenomena that may exist (such as friction between the fibers) into account.

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