Microscopic analysis of cotton nep structure

M. Matusiak[1] and I. Frydrych [1,2]
[1]Institute of Textile Architecture, Lodz POLAND
[2]Technical University of Lodz, Lodz POLAND
Correspondence author iat@iat.com.pl

ABSTRACT

An important quality problem of cotton processing is the presence of neps. The nep concept appeared more than 100 hundred years ago, but so far there is not a unified, univocal, definition acceptable to all researchers. By a nep is generally understood as small, difficult to disentangle knots of fibers or non-fibrous bodies wrapped by fibers. The full assessment of cotton neppiness, reasons for occurrence and changes during processing require knowledge about the nep structure. This kind of knowledge can be obtained by means of microscopic analysis. Nep structure analysis has been a research subject for many times. In such an analysis a microscope enabling a black and white picture was used often. In the present study on nep structure a polarizing microscope was used. The use of the polarizing microscope enabled the inner nep structure and the maturity of fibers in the nep to be obtained under a polarized light. Microscopic images obtained using the polarizing microscope were scanned and stored in the computer. Computer analysis of the images was carried out using the Lucia system. Neps in raw cotton of different origins and in their semi-processed form were analyzed. On the basis microscopic analysis, it was observed that neps in raw and in semi-processed cotton are characterized by a differentiated and unique structure. The biological neps as well as the mechanical ones and others consist of two structural elements: a core, which is a relatively tight centre of tightly entangled fibers, seed coat fragments or inorganic particles, and a loose mass of fibers and their ends surrounding the core. In the majority of neps there are immature and dead fibers. They occur individually or as a fiber clusters. It confirms the theory that cotton maturity influences neppiness and the immature and dead fibers cause nep formation during cotton processing.

Introduction

Cotton neppiness has been an interesting and important quality problem for researchers for many years. Neps occur at all the stages of cotton processing, starting from un-ginned cotton, through ginning, yarn manufacturing and yarns up to and including textile products. The neps reduce the quality of cotton yarn and its appearance. Special problems are caused by the different rates of absorption of dyestuff by neps, which is the reason for dyeing unevenness in fabrics containing neps (Clegg and Harland, 1923).

Over the years a great deal of research were carried out on cotton neppiness, and especially their causes (Bailey, 1930; Barella and Manich, 1992; Butterworth, 1925; Färber, 1996; Frydrych and Matusiak, 1999; Frydrych *et al.*, 2001; Frydrych and Matusiak, 2002). Research has shown that many factors influence the nep formation in cotton. They can be divided into two main groups:

- Factors originating from the raw material properties, connected mainly with cotton maturity, which influence the fibers tendency to entangle and to create neps.
- Factors related to the cotton processing, especially mechanical action, which cause or facilitate nep formation.

Microscopic observations of the nep structure in cotton lint and lint during processing plays an important role in research on cotton neppiness (Hebert *et al.*, 1988; Jacobsen *et al.*, 2001; Lord, 1948). This enabled some questions to be answered concerning the nep size and shape, the number and arrangement of fibers creating the nep, the presence of other non fibrous elements in the nep structure, etc.

On the basis of microscopic observations Pearson provided the first nep classification, dividing all faults occurring in cotton lint, semi-processed cotton and yarn into two main groups (Pearson, 1933):

- Proper neps consisting only of entangled fibers.
- Seed coat fragments with the fibers attached.

In addition to these two main groups, Pearson also referred to seldom occurring faults, similar to neps, consisting of fibers wrapped around other plant fragments, as for example, leaf or stalk fragments as well as foreign matter. To this group Pearson included fragments of compressed fibers, damaged fiber fragments.

In microscopic examinations of the nep structure, light microscopes were mostly used, (rarely scanning microscopes) with black and white images. In the present research on the assessment of the nep structure the polarized microscope was used, which enabled one toto have a color images of the fiber with polarized light, and to assess the maturity of fibers creating the nep.

Measurements were carried out under a grant from the Polish State Committee for Scientific Research (No 7 T08E 05621).

Description of the measurement procedure

The cotton fiber belongs to materials characterized by an anisotropy of light transmission. If the linearly polarized light falls to a fiber, then after passing through the fiber it will be split into two perpendicular polarized rays: (Zurek *et al.*, unpublished work).

If both rays are taken to one vibration plane, by means of an analysis, , the rays will interfere with each other, producing a color image. The observed color depends on the phase displacement between the two rays. With an increase in the elements of the secondary wall of the fiber, the optical length in the fiber increases. Moreover, during the secondary wall development, layers of better-aligned microfibrils occur one by one. Therefore, the fiber maturity determines the phase displacement and interference color used for a cotton maturity assessment, this being standardized in the Soviet standard GOST, and since 1972 has been also introduced for application in Poland according to Polish Standard PN 72/P-04675.

According to the standardized procedure, an analysis is carried out on a fiber placed in a diagonal position (+45°) in relation to polarizing plane. The observed fiber takes a specific interference color dependent on the degree of the secondary wall development.

During the cotton maturity assessment, the interference color of the flat part of the fiber is determined. Depending on the color, the fiber is classified into the following classes:

- Mature fiber – orange with pink-violet sections, golden-yellow, yellow with green sections, green-yellow.
- Not fully mature fiber – yellow-green with blue sections, green with blue sections, blue with dark blue sections, dark blue, sections, dark blue.
- Immature fibers – blue, blue-violet, blue-violet with the purple sections.
- Dead – violet-purple or purple with transparent sections.

In the American standard there is an observation after turning the fibers about 90° (a subtractive arrangement in relation to the plane). In this position, mature fibers are light yellow and immature and dead fibers are yellow-orange and orange (Zurek *et al.,* unpublished).

Experimental procedure

According to definition [ASTM D 1446-71], a nep is "one or more fibers occurring in an entangled and not organized mass". In research on nep structure it is not possible to re-arrange the fiber in cotton without damaging the structure of the nep. Furthermore, not all the fibers in the nep can be observed with the same sharpness, because of the 3-D structure of the nep.

Measurements were carried out in such a way on the microscope that the sharpness of the images was changed to obtain successive sharp images of particular nep layers. Moreover, the object placement was changed in a way enabling one to observe particular fibers or their fragments in a parallel arrangement. Microscopic nep observations were carried out at an objective magnification of 10x. In special cases, especially in the case of large seed coat neps, a magnification of 2.5x was used. Neps were examined from raw materials of different origin and spinning intermediate stages

Usually observed neps were scanned, which reflected relatively large neps. Smaller neps are difficult to observe visually. In total some 100 neps were measured. The nep images were analyzed in respect of their type, size, shape and the number and maturity of the fibers in the nep.

Microscopic images from the polarized microscope were scanned and transferred into a computer. For computer image analysis a LUCIA program was used. On the basis of the observations carried out, it was observed that in the raw cotton and g semi-processed products, there are three kinds of neps:

- Neps consisting of only fibers – such neps being considered to be of a mechanical origin,
- Seed coat neps – neps of biological origin and
- The remaining neps, which are from a source, other than a plant.

Mechanical and biological neps create two basic nep groups in cotton. The other neps are seldom encountered.

Figure 1 presents an example of a nep, the core being an inorganic particle, probably a grain, around which fibers are entangled. The majority these are short fibers or their fragments flat in shape and a blue-violet color, i.e. not mature.

Among the neps of mechanical origin were neps consisting of a few or several entangled fibers as well as neps involving a larger number (difficult to calculate) of fibers (Figure 2). The compactness of the fiber entanglement and fiber arrangement is often different for neps. Observation of a few dozen neps of mechanical origin showed that their structure differed considerably. Nevertheless, they all exhibited two common features:

- A nep core, having a relatively high density of fibers; which are entangled and compact, it is being difficult to determine the fiber color as well as which element belongs to which fiber,
- A loose fiber mass surrounding the core consisting of non-parallel fiber ends, from the nep core.

It was found that in the structure of these neps there are fibers of different maturity. Nevertheless, in the majority of neps, immature and dead fibers were noticed. On the basis of this, it can be concluded that immature or dead fibers initiate the formation of the nep structure, around which the neighboring fibred are twisted or entangled as a result of mechanical forces.

Among the mechanical neps, there were neps, which were not caused by immature and which are generally long fibers. A large oval core characterizes these neps. Among the fibers arranged parallel to the compressor axis (angle of 45° in relation to the horizontal line) flat fiber fragments of the following colors: violet, brown, dark blue and transparent, were clearly visible.

Some of these neps (due to their large size) can be observed as a whole at an objective magnification (2.5x), which does not allow assessing the shape and color of particular fibers. The assessed section of the neps was therefore observed at an objective magnification of 10x. With this magnification single fibers forming the nep can be assessed. Their shape and color showed that they were immature and dead. Neps of biological origin also consist of 2 structural components, namely: seed coat fragments and mounted to the fibers or fiber ends attached to them. They can be individual fibers of a different color and maturity (Figure 3), as well as a whole assembly of fibers, the majority of which are immature. Biological neps are usually large, to the whole nep and can only be observed under an objective magnification of 2.5x.

Some large neps were of a compound form; consisting of both biological and mechanical neps. Although an objective magnification of 2.5x was used, it was clearly evident that neps were formed by dead fibers: flat, without convulations, of a violet or transparent color.

Summary

On the basis of microscopic observations of nep structure it emerged that neps in raw cotton and in semi-processed cotton are characterized by widely different structures. Neps of both biological and mechanical origins as well as other types of neps, consist of two structural elements, namely: a nep core, which can be a concentration of compact entangled fibers, seed coat nep fragments or inorganic particles and surrounding the core a loose mass of fibers and their ends.

In the majority of the neps immature and dead fibers are found. They occurred individually or in groups. It confirms that immature and dead fibers of the cause of neps being formed.

References

- ASTM D 1446-71. Standard Method of Test for Number of Neps in Cotton Samples.
- Clegg, G.G. and Harland, S.C. (1923). Neps in Cotton Fabrics and their Resistance to Dyeing and Printing, *J. Textile Inst.,* **14**: T 125.
- Bailey, M.A. (1930). The Causes of Nep in Cotton and the Possibilities of its Prevention with Special Reference to the Sudan, Empire Cotton Growing Corp., Conference of Cotton Growing Problems, 17.
- Barella, A. and Manich, A. M. (1992). The Statistical Distribution of the Neps Size in Raw Cotton Stocks According to the „Uster AFIS System", International Cotton Conference, Bremen.
- Butterworth, G. (1925). Study of Cotton Neps. *Text. World*, **67**: 3867.
- Färber, C. (1996). Einfluss des AFIS - Störpartikelgehaltes auf die Imperfektionen von Baumwoll-Ring- und Rotorgarnen, Mell. *Textilber*, **10**: 652.
- Frydrych, I. and Matusiak, M. (1999). Cotton Neps in the Technological Process. *Fibers and Textiles in Eastern Europe,* **1**: 24.
- Frydrych, I., Matusiak, M. and Swiêch, T. (2001). Cotton Maturity and its Influence on Nep Formation. *Tex. Res. J.* **71**: 595-604.
- Frydrych, I. and Matusiak, M. (2002). Predicting the Nep Number in Cotton Yarn-Determining the Critical Nep Size. *Text. Res. J.*, **72**: 917.
- GOST 3274.2-72, Волокно хлопока. Ускоренные методы определения сорта и линейной плотности (толщины).
- Hebert, J.J., Boylston, E.K. and Thibodeaux, D.P. (1988). Anatomy of a Nep. *Text. Res. J.*, 380.
- Jacobsen, K.R., Grossman, T.L., You-Lo, Hsien, Plant, R.E., Lalor, W.F. and Jernstedt, J.A. (2001). Neps, Seed-Coat Fragments and Non-Seed Impurities in Processed Cotton, *Cotton Sci*., **5**: 53.
- Lord, E. (1948). Neppy Cotton: Origin and Cure. *Emp. Cotton Grow. Rev.*, **25**: 180.
- Pearson, N.L. (1933). Neps and Similar Imperfections in Cotton. *Department of Agriculture Technical Bulletin,* **396**.
- PN-88/P-04675, (1988). Cotton, Cotton Determination of Maturity Coefficient.
- Zurek, W., Greszta, M., Frydrych, I. and Balcar, G., (unpublished work).

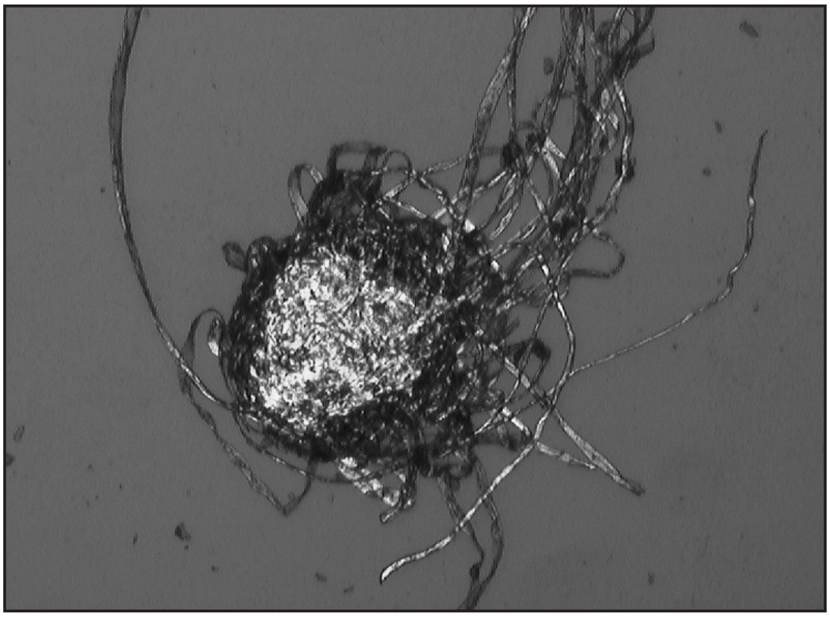

Figure 1. *An example of a microscopic image of a nep of inorganic origin.*

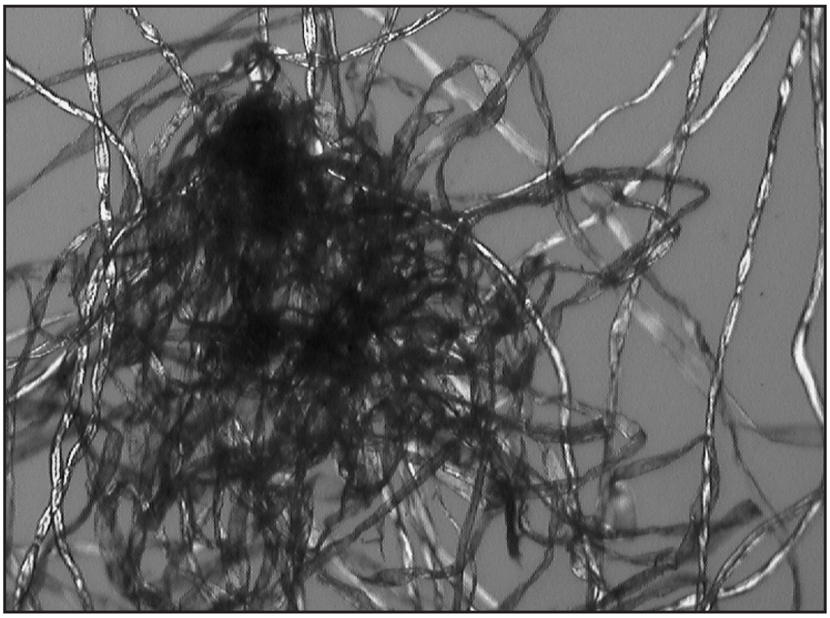

Figure 2. *An example of a microscopic image of a nep of mechanical origin.*

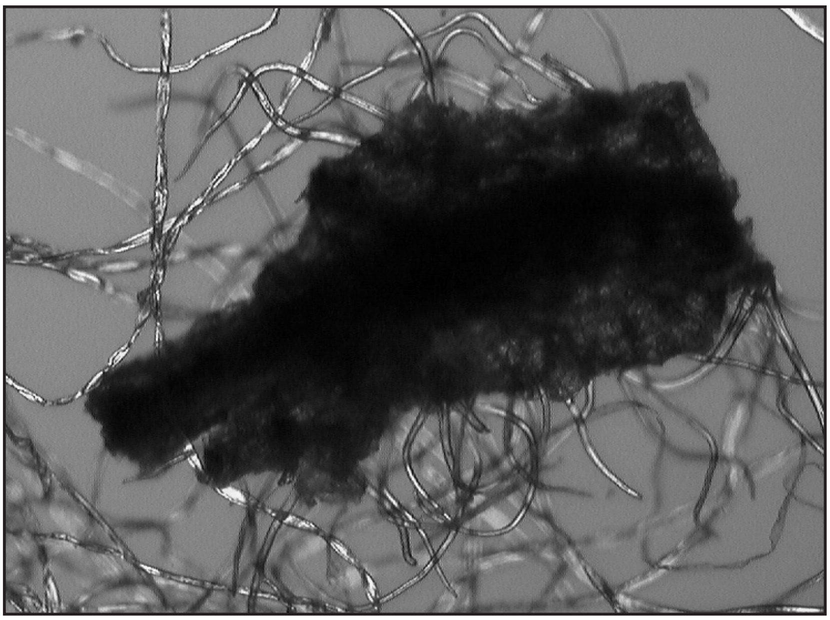

Figure 3. *An example of a microscopic image of a nep of biological origin.*