NEP BALANCE IN COTTON DURING PROCESSING IT INTO A YARN

Iwona Frydrych[1,2], Małgorzata Matusiak[1]
[1)] Institute of Textile Architecture,
276 Piotrkowska Str. 90-950 Lodz, Poland,
e-mail:iat@iat.com.pl
[2)] Technical University,
Faculty of Textile Technology
Department of Clothing Technology
36 Żwirki, 90-539 Lodz, Poland,
e-mail:frydryc@ck-sg.p.lodz.pl

KEYWORDS

industrial process, industrial engineering, manufacturing, forecasting, deterministic model

ABSTRACT

Neppiness is one of the main quality problems of cotton yarns, especially designed for production of high quality fabrics for apparel. Neps and trash a contained in processed raw cotton are the nep source in yarn. Nevertheless, not all the neps and trash being in raw cotton are transferred into to the yarn and are registered by the Uster Tester as a yarn faults. During the processing in the spinning mill the nep and trash number is changed; therefore, the nep number in semi-products, from which the yarn is created differs significantly from the nep number in the initial raw material. Predicting the cotton yarn neppiness demands the evaluation of the nep number in roving, from which directly the yarn is formed.

In the paper there are presented models of nep balance in the technological process basing on diagnostics by the AFIS system in the spinning mill. The models were elaborated for carded and combed spinning systems.

Elaborated nep balances enable predicting the nep number in 1 gram of roving feeding the ring spinning frame, what creates the starting point for further consideration in direction of predicting the nep number per 1000 m of cotton yarn.

1. INTRODUCTION

One of the most important cotton yarn quality parameters is the nep number per 1000 m. Nep presence influences the yarn appearance and produced from it fabrics, their smoothness as well as dye evenness (Artzt 1957, Frey 1999).

The nep source in the yarn are neps and trashes contained in the raw material used for production (Färber 1996). Nevertheless, not all the neps and trashes being in cotton are transferred into the yarn and are registered by the Uster tester as the yarn faults. During the technological process the nep and trash number change.

Trash removing takes a place during the preliminary cleaning and opening, carding and combing. In the case of neps there is observed initially an increment of their number in the scutching room, next – a significant reduction due to the carding and combing (Artzt, Gresser and Maidel 1995; Furter and Frey 1991; Frydrych and Matusiak 1998). Therefore, the nep number in semi-products, from which the yarn is created, i.e., in the roving feeding the ring spinning frame and in the sliver feeding the rotor spinning frame differs significantly from the nep number in the entering raw material (Kluka, Matusiak and Frydrych 1998).

Many authors have been working for many years on a problem of cotton neppiness (Färber 1998, Frey 1994, Peters and Söll 2000). Nevertheless, it is still not solved in a complex way, but it is very important cotton yarn quality problem especially for yarns designed for very high fabric quality.

Predicting a cotton yarn quality in the aspect of their neppiness requires first of all the nep and trash number evaluation in the sliver or roving, from which the yarn is directly created. It is possible to know the nep number in raw material used for production and effectiveness of work of spinning machinery being in the technological order.

2. THEORETICAL PART

2.1. Model of the nep balance in cotton during processing basing on a diagnostics process in the spinning mill using the AFIS system

Knowing a character of the nep number changes in cotton during the processing we can prepare the nep balance basing on diagnostics of the technological process by the AFIS system.

During the preliminary cotton fiber treatment in the scutching room there is the nep number increment. It is due to the mechanical action of working elements of cleaning and opening machines and pneumatic fiber transport. The nep number increment during the processing in the scutching room depends on the processing conditions, among the others adjustment of machinery working elements, climatic conditions, underpressure, rotary speed of the cleaning elements and so on, as well as on fiber characteristics, especially these parameters, which influence the fiber ability for nep creating. Due to the fact that it does not depend on the initial nep number in raw material N_c, the increment of the nep number ΔN_t during the processing in the scutching room should be expressed in absolute values. Therefore, the nep number per 1 gram in the web delivered from the scutching machinery can be expressed by equation (1):

$$N_t = N_c + \Delta N_t \qquad (1)$$

where:

N_t - the nep number per gram in the fiber stream delivered by the opening and cleaning machinery (in a lap or web),
N_c - the nep number per gram in raw material,

ΔN_t - increment of the nep number per gram as a result of preliminary treatment in the scutching room.

During the carding there is a reduction of the nep number being in the web feeding the carding frame. Its amount depends on many factors, among the others the degree of utility and cleanness of covering of main cylinder, licer-in and flats, general technical shape of machinery, cylinder rotary speed, adjustment working elements of machines, and so on.

Parameter characterizing the carding machine effectiveness in the aspect of nep reduction is Nep Removing Efficiency (NRE%), which is expressed by equation (2):

$$NRE_{card} = \frac{N_{feed.card} - N_{del.card}}{N_{feed.card}} \cdot 100\% \qquad (2)$$

where:
NRE_{card} - nep removing efficiency by the carding frame,
$N_{feed.card}$ - the nep number per gram in a web (or lap) feeding the carding frame,
$N_{del.card}$ - the nep number per gram in the sliver delivered by the carding frame.

From the eq.(2) the nep number in gram of sliver delivered from the carding frame can by expressed as follows:

$$N_{del.card} = N_{feed.card}\left(1 - \frac{NRE_{card}}{100}\right) \qquad (3)$$

The nep number in fiber stream feeding the carding frame corresponds to the nep number in the fiber stream delivered by opening and cleaning machines:

$$N_t = N_{feed.card} \qquad (4)$$

This equation (3) can be written as follows:

$$N_{del.card} = \left(N_c + \Delta N_t\right)\left(1 - \frac{NRE_{card}}{100}\right) \qquad (5)$$

In the carded system the sliver delivered by the carding frame is drawn by the drawing frames (breakers or finishers), and next, stretched on the roving frame. At a correct technological process during the drawing and preliminary spinning procedures there are not seen the significant changes of the nep number in the processed fiber stream. Therefore, the nep number per 1 gram of sliver from the carding frame corresponds to the nep number per 1 gram in sliver from the drawing frame and of roving:

$$N_{del.card} \approx N_{rov\,card} \qquad (6)$$

where:
$N_{rov.\,card}$ - the nep number in carded roving.

Finally, the nep number in the roving from the carded system can be expressed by:

$$N_{rov.card} = \left(N_c + \Delta N_t\right)\left(1 - \frac{NRE_{card}}{100}\right) \qquad (7)$$

Neps contained in the roving – $N_{rovcard}$ are transferred into the yarn produced from this roving. Nevertheless, as was mentioned above [3,5] not all neps are visible for the human being eye and for the measurement device, for example, Uster tester, so not all of them create the source of the neps in the yarn. The nep size in the roving and its distribution are of a great importance.

In the combed system there is also an additional stage, in which the nep reduction in the processed fiber stream has a place. This stage is the combing process. Nep removing efficiency by the combing frame is defined analogously as for the carding frame:

$$NRE_{comb} = \frac{N_{feed.comb} - N_{del.comb}}{N_{feed.comb}} \cdot 100\% \qquad (8)$$

where:
NRE_{comb} - nep removing efficiency by the combing frame in %,
$N_{feed.comb}$ - the nep number per gram in a lap feeding the combing frame,
$N_{del.comb}$ - the nep number per gram in sliver delivered by the combing frame.

Basing on equation (8) the nep number per gram in sliver after combing can be calculated in the following way:

$$N_{del.comb} = N_{feed.comb}\left(1 - \frac{NRE_{comb}}{100}\right) \qquad (9)$$

During the drawing after the carding process as well as during the doubling there shouldn't take place significant changes of neps in processed fiber stream. Thus, the correct is equation:

$$N_{del.card} = N_{feed.comb} \qquad (10)$$

Therefore, the equation on the nep number in a sliver delivered by the combing frame, and in the same way in roving created from the sliver after combing can be described by the equation:

$$N_{del.comb} = \left(N_c + \Delta N_t\right)\left(1 - \frac{NRE_{card}}{100}\right)\left(1 - \frac{NRE_{comb}}{100}\right) \approx N_{rov.comb} \qquad (11)$$

where:
$N_{rov.comb}$ - the nep number per gram in roving after combing.

The derived equation determines the relationship on the nep number in roving made by the combed system in the function of the nep number N_c in cotton used for processing and acting efficiency of machinery: scutching room – ΔN_t, carding frame – NRE_{card}, combing frame – NRE_{comb}.

2.2. Determination of parameters characterizing the spinning machinery efficiency

Parameters characterizing the machinery work in the technological order: ΔN_t, NRE_{card}, NRE_{comb}, can be determined basing on intermill diagnostics carried out in the spinning mill using the AFIS system.

The AFIS system is a basic tool applied in the world spinning mills for checking and optimizing the technological process. On the basis of AFIS results for semi-products feeding and delivered by a given spinning machine its work correctness is assessed not only in the aspect of the nep removing, but also the cleaning efficiency, degree of fiber destruction and so on. These results can be used for calculation of the mean values of parameters NRE_{card} and NRE_{comb} for group of machines being in the technological order, on which the production is carried out. Quality results, i.e., the nep number per gram of roving produced from a blend of fibers of known characteristics, can be predicted on the basis of equations (7) and (11).

The value of NRE for a given machine does not change in a significant way in a long period of time. Analysis (Furter and Frey 1991) showed that the nep removing efficiency by the carding frame is maintained on the similar level during 16÷18 weeks after upgrading of the carding frame coverings.

Also the nep removing efficiency by the combing frames does not change in a long period of time. Moreover, it was stated (Kluka and Matusiak) that at a correct machine adjustment there are not any significant differences in aspect of nep removing efficiency between the particular machine heads.

Parameter characterizing an increment of the nep number ΔN_t during processing in the scutching room can be also determined basing on an analysis of this stage of processing by the AFIS system. This parameter should be determined separately for each kind of fiber blend.

The technological process in the initial stage, i.e., during the opening and cleaning in the scutching room, depends on the quality of processed raw material, especially its contamination, which influences the cleaning ability. Dependably on cotton cleaning ability there is chosen an appropriate set of machinery, the number of cleaning points and the working elements of opening-cleaning machinery are appropriate adjusted.

Above factors cause that, for example, long staple roller ginned cotton of big trash content requires more intensive cleaning than middle staple cotton better cleaned by saw ginning. The differences can concern not only the cleaning points and their adjustments, but also machine configuration, what implies the pneumatic transport conditions, which is one of the most important factors causing the nep increment in cotton during the processing in the schutching room.

Therefore, for each group of opening – cleaning machinery for a given blend of raw material the mean value of parameter ΔN_t, characterizing the absolute value of nep increment during the processing on this kind of machinery should be determined separately.

In order to assure the highest reliability of determined values of parameters characterizing the effectiveness of machinery (ΔN_t, NRE_{card} and NRE_{comb}) for the each spinning mill there should be determined individually the frequency of measurements of particular machines and process stages by the AFIS system. We should also take into consideration the frequency of machinery maintenance, upgrading of coverings of carding frames, a kind and technical shape of machinery and the other conditions.

3. EXPERIMENTAL

In order to verify the theoretical model of nep balance in cotton during the processing it into a yarn the measurements were carried out during the manufacturing the cotton blend from the Central Asia by the carded and combed processes.

Basing on the AFIS analysis of machinery working in the technological order the parameters characterizing the machinery work in the aspect of nep removing were evaluated, and next, on its basis the mean value of nep removing efficiency was calculated for particular spinning stages.

The nep removing efficiency was determined by measuring on the AFIS system:

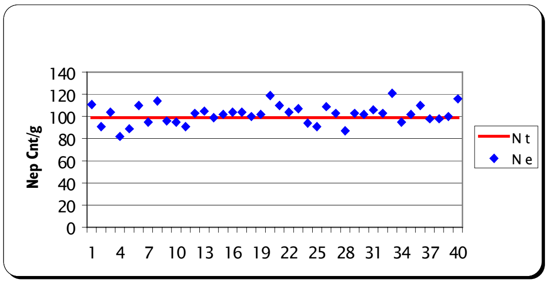
– the nep number per 1 gram of semi-products feeding the particular machines,
– the nep number per 1 gram of semi-products delivered by the particular machines in the technological order.

The blend of known nep characteristics was processed on the examined machinery. The majority of laydown was processed by the carded system producing the roving designed on the ring – spun yarns of linear densities 20, 25, 30 and 50 tex.

Part of cotton for production of the roving designed for combed yarns of linear density 15 tex was combed (18% of noils).

The produced roving was measured by the AFIS system. Due to the fact that the roving was designed for production of yarns of different linear densities, the samples were taken randomly from the spinning frames used for production of different yarn assortment. From roving frame of each machine 10 cones of roving after carding and 6 cones of roving after carding and 6 cones of roving after combing were taken.

Totally – 46 samples of roving were examined doing 10 repetitions for each sample. In Figure 1, there is presented a comparison of the calculated and real nep number in the roving.



Figures 1. Calculated and real nep number in roving

3.1. Assessment of agreement of predicted and real nep number in the roving

Assessment of agreement of the predicted and real nep number in the roving was carried out by the t – Student's test.

The significance difference between the assumed value and a mean value from the sample was stated for rovings designed for production of particular yarn assortments. The calculated values of statistics are presented in Table 1.

Table 1. The significance of differences between predicted and real value of the nep number in roving

Parameter	Roving designed for yarn				
	15 tex	20 tex	25 tex	30 tex	50 tex
$\bar{a}$	46	99	103	101	105
SD	1.80	10.58	6.94	7.77	8.43
A_z	48	99	99	99	99
t	**1.86**	**0.00**	**1.73**	**0.77**	**2.14**
$t_{k,0.95}$	2.57	2.26	2.26	2.26	2.26

$\bar{a}$ – mean value from measurements,
SD – standard deviation,
A_z – value calculated according to the model (assumed value),
t – t - Student's variable,
$t_{k,0.95}$ – critical value of t-Student's variable at k degrees of freedom and probability 0.95.

On the basis of predicted results it was stated that there is not a statistically significant difference between the predicted nep number in the roving and real nep number determined by the AFIS.

The presented analysis confirmed the correctness of – proposed theoretical models. Elaborated equations describing the balance of nep number in cotton during the processing by the carded system – equation (7) and by combed system – equation (11) enable the predicting with a big preciseness the nep number in the roving on the basis of known nep content in the raw material used for production in the technological order of known work efficiency of machine.

4. CURRENT STAGE OF THE WORK

Presented nep balance (11) enable estimation of the nep number in 1 g of roving feeding the ring spinning frame, what is a starting point for further considerations in order to predict neppiness of cotton yarn.

The nep number per 1000 m of yarn can be found from the following relationship:

$$N_{UT} \approx n \cdot N_{rov} \cdot Tt_p \qquad (12)$$

where:

Tt_p – yarn linear density,

n – percentage of neps of size equal to or higher than the critical nep size for a given yarn linear density in the total roving nep number,

N_{rov} – the nep number per gram in roving on the basis of nep balance (11).

For the elaborated equation we introduced n value, which express the share of neps of size equal to or higher than the critical nep size for a given yarn linear density in a total nep number in roving.

The theoretical relationship allowing determining the critical nep size in the ring spun yarn of a given yarn linear density were elaborated in the frame of grant (No 7 T08E 0561 Supported by Polish Scientific Council), part of which is presented here.

It was also determined experimentally the nep share of size equal to or grater than the determined value in a total nep number in roving produced by the carded system. The method for determination of interval, in which the predicted nep number per 1000 m of ring spun yarn should be placed, was elaborated.

The proposed procedure can be used choosing the raw material for the blend production in the aspect of obtaining the required, determined by the client yarn quality.

5. SUMMING UP

Analysis of knowledge on the theme of this research and theoretical considerations allowed derivation of theoretical relationships describing the changes of the nep number in cotton during the processing by carded and combed system. In a similar way, the trash balance in cotton during the processing can be elaborated, and next, trash content in the roving can be evaluated.

The experimental verification confirmed the correctness of proposed models. The proposed model of the nep number enables an evaluation of the nep number in the roving basing on known nep characteristics of raw material and effectiveness of spinning machinery work in the technological order basing on technological process diagnostics using the AFIS system. The calculated nep number in the roving creates the starting point for further considerations to predict the nep number per 1000 m of yarn.

5. LITERATURE

Artzt P., 1957. Nissen in der Ausrüstung, Textilpraxis, 7/57, 668-673.

Artzt P., Gresser G., Maidel H., 1995. Einfluβ von Trashgehalt und Reinigungswilligkeit der Baumwolle auf die Garnqualität, PTB Garn- und Flächenherstellung, **2**, 14-21.

Färber Ch., 1996. Einfluβ des AFIS-Störpartikelgehaltes auf die Imperfektionen von Baumwoll-Ring- und Rotorgarnen, Melliand Textilberichte, **10**, 652-655.

Färber Ch., Relationships Between Cotton Fiber Properties and Mill Processing Results from Bale to Card Sliver. *II World Cotton Conference*, Ateny (1998).

Frey M., 1999. Erfordeliche Garnqualitätsmerkmale für die Weiterberarbeitung sowie das Aussehen des Flächengebildes, Zellweger Uster A G, Switzerland.

Frey M., Schleth A., Examples of Data Acquisition for Fibres and the Application in the Spinning Mill, *International Cotton Conference,* Brema (1994).

Frydrych I., Matusiak M., 1998. Practical Application of AFIS system in the Cotton Industry, Textile Revier, **8**, 6-12.

Furter R., Frey M., 1991. Analyse des Spinningprozesses durch Messung von Zahlen und Gröβe der Nissen, Melliand Textilberichte **7**, 504-510.

Kluka A., Matusiak M., 1998. Report from Grant no 1986/C/T09-3/97 “Starting the Production of Combed Yarns of Low Linear Density and High Quality Standard by Application of Modern Spinning Techniques on the Basis of Pilot Measurement of Machinery Order”, Lodz.

Kluka A., Matusiak M., Frydrych I., 1998. Yarn Neppiness – Influence of Raw Material Quality and Process Technology, Melliand Textilberichte,**7-8**, E137-138.

Peters G., Söll W., Determination of Trash and Dust Content in Yarns, Melliand Textilberichte, 1-2, (2000).